AD-A036 617 CORPS OF ENGINEERS NEW YORK NORTH ATLANTIC DIV F/G 8/6

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. ANNEX 1.(U)

MAY 72

UNCLASSIFIED NL

1 OF 4

AD A036617

North Atlantic Regional Water Resources Study

NAR

Annex 1
to Report

Errata of Report and Annex 1
North Atlantic Regional Water Resources Study
September 31, 1972

REPORT

Page	
126	The Industrial Self-Supplied Water need is for fresh water only and does not include brackish and saline water. The costs and devices for this need are for all types of water.
192	The cost for "Flood Damage Reduction - mainstreams" should be 790 in 1980 rather than 700.
195	The need for "landscape maintenance-diversity" should be 10.3 in 2020 rather than 10.2

ANNEX 1

Page	
18	The Industrial Self-Supplied Water need is for fresh water only and does not include brackish and saline water. The costs and devices for this need are for all types of water.
88,89	The needs for "mainstream Flood Damage Reduction" and "tidal and hurricane Flood Damage Reduction" should be 0.04, 0.04, 0.09, 0.18 and 0.01, 0.02, 0.04, 0.07 respectively for the present and three target years for both the mixed objective and the National Income objective. The present figures are 0.036, 0.043, 0.090, 0.180, and 0.014, 0.017, 0.036, and 0.070.
126	The device "mainstream storage reservoirs" should be 53 in 2000 rather than 54 for the mixed objective.
140	The cost for "Flood Damage Reduction - mainstream" should be 90 in 1980 rather than 0 for the mixed objective. The summation of costs in 1980 should be 2200 rather than 2100.
250,251	The device "ocean-Local Flood Protection" should be 0 in 1980 for the mixed objective and all single objectives rather than 1.
300,301	The device "ocean-Local Flood Protection" should be 2 in 1980 for the mixed objective and all single objectives rather than 1.

The North Atlantic Regional Water Resources (NAR) Study examined a wide variety of water and related land resources, needs and devices in formulating a broad, coordinated program to guide future resource development and management in the North Atlantic Region. The Study was authorized by the 1965 Water Resources Planning Act (PL 89-80) and the 1965 Flood Control Act (PL 89-298), and carried out under guidelines set by the Water Resources Council.

The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners representing some 25 Federal, regional and State agencies. The NAR Study Report presents this program and the alternatives as a framework for future action based on a planning period running through 2020, with bench mark planning years of 1980 and 2000.

The planning partners focused on three major objectives -- National Income, Regional Development and Environmental Quality -- in developing and documenting the information which decision-makers will need for managing water and related land resources in the interest of the people of the North Atlantic Region.

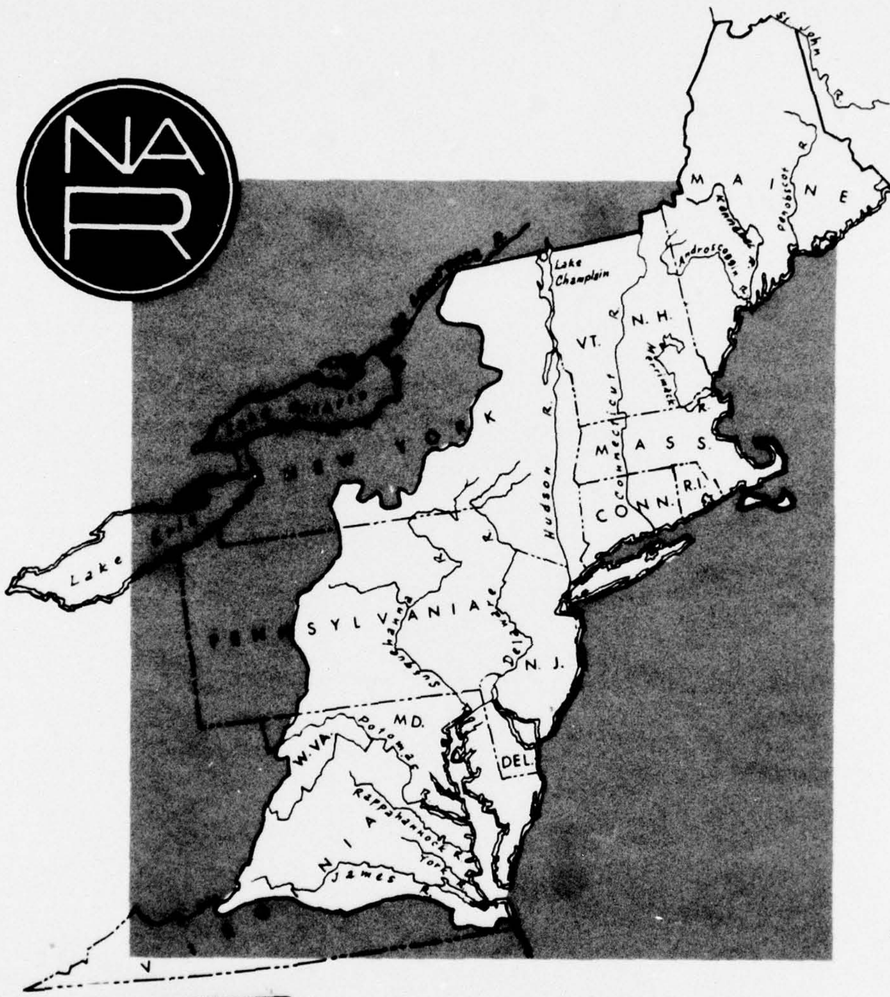
In addition to the NAR Study Main Report and Annexes, there are the following 22 Appendices:

A. History of Study
B. Economic Base
C. Climate, Meteorology and Hydrology
D. Geology and Ground Water
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas
F. Upstream Flood Prevention and Water Management
G. Land Use and Management
H. Minerals
I. Irrigation
J. Land Drainage
K. Navigation
L. Water Quality and Pollution
M. Outdoor Recreation
N. Visual and Cultural Environment
O. Fish and Wildlife
P. Power
Q. Erosion and Sedimentation
R. Water Supply
S. Legal and Institutional Environment
T. Plan Formulation
U. Coastal and Estuarine Areas
V. Health Aspects

WATER RESOURCES NEEDS AND POTENTIALS FOR AN EXPANDING SOCIETY

1

Annex 1
to Report



Prepared by

North Atlantic Regional Water Resources Study Group
North Atlantic Division
Corps of Engineers, U.S. Army

for the

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
COORDINATING COMMITTEE

TABLE OF CONTENTS

LIST OF FIGURES

AREA MAPS

LIST OF TABLES

TABLES OF NEEDS

TABLES OF DEVICES

TABLES OF COSTS

CHAPTER 1

INTRODUCTION

The twenty-one Area Programs presented in this Annex are the most detailed recommendations of the NAR Study and provide background information for the Regional Program of the NAR Report. These Area Programs were agreed upon by plan formulation work groups and were reviewed and approved by the NAR Coordinating Committee. The Programs are based on detailed information found in the Appendices.

The NAR Study has used some new means of planning but the basic activities have not changed. Data gathering, projections and decisions among alternatives are still these basic activities. These activities have been explained in general terms in the NAR Report and in detail in Appendix T, Plan Formulation.

Area Programs serve a central role in the planning activities of the NAR Study. It became clear during Plan Formulation that detailed descriptions were required of the choices made between alternatives. Since the choices were based on explicit assumptions about each alternative the implications of choosing among the alternatives could only be understood by fully describing the choices and the alternatives. These 21 descriptions of choices allow planners to easily and fully re-evaluate their decisions and allow the public to evaluate the recommendations.

The following Chapter describes the contents of the Area Programs and the procedures and assumptions used to formulate them.

CHAPTER 2

METHODOLOGY

These Area Programs describe the decisions about alternatives made by the Program Formulation Work Group of the NAR Study.

The Area Programs present the problems and recommended solutions for water management in each of the 21 NAR Areas. At this level of planning individual projects are not considered and only total quantities of water are considered for each Area under any one need and device.

All of the Area Programs contain similar information presented in the following sequence:

Area Map
Area Description
Possible Alternative Planning Objectives
Recommended Mixed Objective
Needs
Devices
Benefits
Costs
Alternative Programs
Tables - Needs
Devices
Costs

Important aspects of each section of the Area Programs are explained here.

Area Descriptions. Each Area is described to give the reader a succinct impression of the outstanding characteristics which affect decisions about the Area's water resources management programs.

Each Area's physical characteristics are described first. The location of each Area and sub-area is given. This includes listing the river basins and States that comprise each Area and describing where sub-areas are located. The size of each Area and sub-area is given in square miles and major tributaries and lakes are listed.

Special characteristics of the Area are then described including general topography, dominant types of vegetation, and large population centers.

Land use and other categories developed in Appendix N, Visual and Cultural Environment, are used to describe the landscape of each Area. The percentages or general proportions are presented for different types of land use, landscapes and visual qualities in the Area. Special features of the Area are mentioned, including unusual parks, forests, monuments, recreation centers, wilderness areas or ecological features such as marshes or estuaries.

Social and economic characteristics of each Area are described next. A description of an Area's historical development is presented if it is pertinent to water resources. Present levels and projections are then given for populations and population densities of the Areas and sub-areas; for the Area's per capita income in relation to the National average; for employment; and for percentage of unemployment. Industries are also listed which presently have and are expected to have the largest levels of employment.

The present level and future possibilities for water development are described last. Summary data on water are presented, including quantities available, its quality and what water users are the largest.

A detailed description is then given of the availability of water which includes average annual water run-off in the Area, the present level of development and the practical limits to which this run-off can be developed.

The management and availability of water supplies are explicit in the determination of an Area's water oriented needs and the devices, consistent with the recommended objective, to meet these needs. Chapter 4 of the Report describes the water development criteria that provides a measure of the water available for use in each Area. The Report defines presently available water resources, practical surface water development, ground water development, and total developable resource.

These summaries at the end of each Area Description present the results of a water resource analysis for each of the 21 Areas. Included are data for average annual runoff and the existing minimum monthly flow with a shortage index of 0.01. Corresponding seven-day minimums are given both in terms of flow and as a percentage of the minimum monthly discharge. Allowances are given for storage and water export, where applicable, and for consumptive losses. These then determine the existing firm resource available for use. The practical limit of development within each Area is presented as the maximum available resource in terms of flow (m.g.d.) and as a percent of average runoff. The potential sources that would allow for this development is then delineated as percentages of major storage, upstream storage, and ground water development.

Delineation of sub-areas was based upon rough views of hydrologic characteristics and of densities of population and industry. Sub-areas are used in these descriptions as a means of referring to general differences within an Area which seem to be important enough to affect decisions.

Possible Alternative Planning Objectives. This section contains descriptions of alternative objectives that could be emphasized in each Area and describes the characteristics of the Area that might lead to choosing each one. An effort is made here and in the section on Alternative Programs to present enough information so that people concerned with water resources management decisions in the Area can understand the implications of choosing among the available alternative objectives. When the implications are understood each person can make up his own mind about the best course of action that should be taken in an Area -- whether or not the action corresponds to any of the actions recommended in the NAR Study.

Recommended Mixed Objective. The major decision during the formulation of each Area's Program was agreement upon the mixed objective to be recommended for that Area. The mixed objective for each Area is described in this section along with the rationale for making the recommendation.

The mixed objectives for each Area represent the judgment of the Coordinating Committee and include the aspirations of State members of the Coordinating Committee, together with the views of Federal Agencies and River Basin Commissions. Any information included in the Area descriptions may serve as rationale for these recommendations, including physical, social, historical or economic characteristics. These decisions have been made according to Study participants' familiarity with and their resultant expectations for each Area. The objective mixes are not just the participants' desires for what an Area should become but reflect their expectations of what it is likely to become. The participants have considered various types of trends in each Area and what the Area's resources will allow.

Needs. General descriptions of each of the fifteen needs are presented here. The needs and the manner in which they are projected are defined in general terms in the NAR Report and in more specific terms in the appendices to the Report. The needs include:

Publicly supplied water
Industrial self-supplied water
Rural water
Irrigation water
Power plant cooling water
Hydroelectric power generation
Navigation
Water recreation
Fish and wildlife
Water quality maintenance
Flood damage reduction
Drainage control
Erosion control
Visual and cultural environment
Health

The sizes, growth rates, location differences, timing and reasons for choosing each need are included in this description. The most important and key needs are also mentioned. A need's importance is appraised by its value to the achievement of the Area's recommended mixed objective. A need may be important because of its size or growth rate or the costs and benefits that are derived from its fulfillment. Key needs are those which must be fulfilled before other needs that are greatly dependent upon the one need will be fulfilled. Water quality management is often key to the fulfillment of other needs that depend upon it -- such as water recreation -- and often important to the mixed objective because of its size.

The largest and fastest growing needs are mentioned next. These appraisals are based on a comparison of the magnitude of the needs among the Areas. For each need, Areas were ranked by the size, growth rate and per capita size of that need. Each need of each Area is then described according to its ranking among the Areas. If the size of an Area's need, for instance, is among the top four of all the Areas it is called a very large need. Other appropriate terms are used for the description of each Area's needs according to their places in the rankings.

This ranking procedure means that each need of an Area is compared in its size and growth rate with the needs of other Areas. This comparison is tempered, however, by the per capita size of each need. This means that the appraisal of each need's size is adjusted by that need's ranking on a per capita basis. A "large" need, for instance, may be called "very large" if it is also very large on a per capita basis.

Location differences in size, growth rate or importance, are explained for each need in an Area if they are known. These differences are described primarily on a sub-area basis or for special sections of Areas such as population centers and wilderness areas.

Timing is also described for each need, including significant changes in sizes or growth rates between planning periods. Those needs which are classified as important or key, however, are so classified only for the 1980 planning period. The important and key needs should change as the recommended program is carried out and it is difficult to predict these changes. The "Present" time period for all needs is 1965 or very close to that year.

Reasons for the sizes, growth rates, timing and locations of needs are usually given for the largest, fastest growing, key and most important needs. Reasons are given for the intermediate and smaller needs when they are of some importance to achieving the Area's recommended mixed objective.

These reasons for need characteristics are closely related to the assumptions that were made about the growth rates of each of the

water related needs under each of the three objectives. These assumptions were made by the agencies responsible for defining and projecting each need for which they were responsible. The assumptions relate a growth rate of a need to certain social, physical or ecological occurrences in an Area that would change depending upon the objectives followed. Lower population growths were assumed for Areas where the people would follow Environmental Quality objectives. There seem to be many social pressures among the people of such Areas that encourage such population changes. Higher industrial productivity is assumed for Areas where the people follow Regional Development objectives because increases of outside investments into such an Area are made with that result in mind. National Income objectives are followed because people believe that the economy of their Area is functioning well or, at least, it can recover by itself if there are economic problems.

Agencies have made additional or even different assumptions for their particular needs under the three objectives. Power plant cooling needs, for instance, are based much more upon the availability of water in any one Area than merely upon the need for electricity. Similarly, water recreation need estimates are based on the location of the resources in addition to the location of the people who have the need.

The reasons are given in this section for having chosen during Program Formulation a projected level of a need for an Area. These reasons are generally characteristics of the Area or of the objective in relationship to the Area which call for choosing particular need levels so that the recommended mixed objective can be achieved.

Several obvious reasons include (1) a high level of water quality maintenance may be required so that clean water will be available for recreation in an Area where Environmental Quality is emphasized, (2) a high growth rate for commercial navigation so that industrial transportation costs can be as low as possible in an Area where Regional Development is emphasized, and (3) a high degree of flood damage reduction so that industrial location sites can be as close as possible to the labor force for an Area where National Efficiency is emphasized.

When an objective was chosen during Program Formulation procedures for emphasis in an Area this did not mean that the size of each need in the Area had to be the size previously assumed to be appropriate for that one objective. Other need levels were often chosen for various reasons. Someone participating in the Program Formulation procedures may have had additional or new information or been more familiar with a particular Area. This person may have realized that a high need level was nearly impossible to achieve in a particular Area or could show that it was not necessary. Such results may have come from errors in the original assumptions for the projections or simply from the person's greater familiarity with the desires of the people in the Area.

Water recreation need levels were frequently changed because of

new information. Recreation can help an Area's Regional Development by having inexpensive facilities, high density use of facilities, or better facilities more lightly used (resulting in a higher quality experience for which vacationers may be willing to pay more). The reasons for choosing any one of these approaches to Regional Development through recreation came from people familiar with local capabilities and desires.

Water quality maintenance is another example. If Environmental Quality is emphasized in an Area where the cost of quality control may affect another objective, the degree of control may be kept at a lower level in the immediate vicinity of industry. This action may be similar to choosing the National Income objective for certain portions of the Area so that present standards would be met.

Similarly, certain devices may change the growth rate of a need in an Area under a specific emphasized objective. Price changes for water supply, for instance, may change people's desires and, therefore, their need for publicly supplied water and most certainly would change their need for water quality maintenance and less urgent needs. Legislation can decrease or stop the use of water for a certain need such as for motor boating, commercial fishing or waste disposal. Legislation can also raise the level of a need such as requiring drinking water to be of a specific quality. This change would not only require increased water quality maintenance but, in turn, may cause rural populations to discontinue using poor quality wells and go on central water systems.

It is because of such reciprocal relationships between objectives, needs, devices, benefits and costs that the decisions among alternatives have been carefully made and carefully and continuously reviewed and revised for each Area and among the Areas.

The needs presented in the Area Program Tables are gross figures and are accumulated over the planning periods. A gross figure means that any given need for a planning period includes those portions of the needs that present programs will already meet. Net needs -- or the needs that no one is presently planning to meet -- are useful for planning decisions but are not available for most needs under the present procedures of data collection.

There are also some figures for needs and devices that overlap -- that are duplications. "Surface acres," for instance, are shown as part of the need under fish and wildlife but this need will partly, if not completely, be met when the withdrawal needs are met by water development devices such as reservoirs. Estimates are shown for the amount of surface area that will be formed by the recommended program but the final quantity of water surface created by reservoirs depends on the actual site used.

Once an Area Program is established all parts of the Program are of approximately equal priority. This is because of the way in which Programs are established. General priorities are established during the

choosing of the mixed objective. More specific priorities are then established step-by-step in the decision process as levels of needs, types of devices and levels of investments are all chosen. The priorities, therefore, are built into or reflected in the Program at this time; they are reflected by the differences in investment, needs levels and timing of the Program. The recommended program has various levels of needs (and costs) as a result of the priorities.

There are certain needs and devices, however, that may be identified as more important or more key to the success of a total program than their numbers or necessary investment levels would imply. These are the needs which are most important to achievement of the Area's mixed objective. Water recreation, water quality maintenance, publicly supplied water and health needs are often in this situation.

Water quality maintenance needs and costs are almost always very large besides being very important to the Area's continued availability of water for withdrawal purposes. Water recreation and visual and cultural needs and costs are often very large but may not be important to the achievement of an Area's mixed objective, especially if Environmental Quality is not emphasized in the mixed objective. Health needs probably do not have large costs and are not important to the mixed objective but would not be lowered because they are basic to other needs of people such as community well being or productivity.

Devices. The recommended mix of devices for each Area is described in this section. These devices were selected because they are likely to fulfill the Area's needs with the maximum return of net benefits. The most important devices are mentioned first. A device may be important because of its relationship to the needs it helps fulfill: the importance of the needs it fulfills; the number of needs it fulfills as a multiple purpose device; certain needs will not be fulfilled unless this one device is used; this device can change the level of needs; the quantity of costs required to obtain the device; or the quantity of benefits the device produces. Key devices are also mentioned and are those which must be used at a certain level for other devices to succeed.

Water development devices are described for fulfilling water withdrawal needs. These devices include upstream reservoirs, mainstream reservoirs, groundwater, inter-Area transfers and desalting. The program for these devices was developed through the use of a supply model described in Appendix T, Plan Formulation. The supply model satisfies water withdrawal needs consistent with the recommended mixed objective of the 21 Areas. Chapter 7 of the Report presents, and generally describes, the parameters used in meeting the water withdrawal needs through water development devices. The Report defines water storage devices, wells, diversion opportunities, and desalting facilities. Chapter 8 presents for each Area data for the water development program as determined through the use of the supply model.

Multiple purpose devices are described, whether or not they are considered important or key, because of the generally widespread part such devices play in fulfilling an Area's needs.

Timing of the use of the more important devices is described. This description concerns the quantity and size of the important devices used during each time frame.

Conflicts concerning devices are described including those which are a result of interferences between two devices or between a device and the fulfillment of a need or the achievement of an objective. The interactions between the devices, needs and objectives that cause the conflicts are also discussed.

Reasons are given for the use of major devices and for their importance, timing and conflicts. Choosing among devices to fulfill the desired levels of an Area's needs is also a process complicated by reciprocal relationships. One device can be used to help fulfill different needs, achieve different objectives and be chosen for different reasons. The general location and size of these devices are briefly discussed along with a list of the needs they help meet.

Relationships between physical and non-physical devices are described as they affect each other while fulfilling certain needs. Reservoirs, local flood protection projects and flood plain management programs, for instance, almost always have the interrelationship where one device can be used in place of another, to at least some degree.

Those needs are explained that cannot be fulfilled by any of the devices in an Area or only fulfilled at an enormous cost. Relationships between Areas are also explained whether they are inter-basin water transfers or are the fulfillment of one Area's needs by another Area's resources without an actual transfer. This latter event occurs most often for water recreation and fish and wildlife needs.

The important and key devices may also be identified in an Area not just by their cost levels and sizes and effects upon needs and other devices but also by their effects upon the types of water used, the degree of multiple uses, the timing of the program, the number of alternative devices available and the importance of the needs they fulfill. Shifts in the level of use of a key or important device are discussed when they require either a shift in the level of use of other devices to fulfill the same level of needs or require a shift in the needs levels themselves.

Uncertainties of the Area's water resources management program are explained. Timing of technological changes have been estimated, particularly for industrial use of water in the demand model. Projection of technological change, however, is generally very difficult.

Most hydroelectric power generation needs in the NAR are filled by pumped-storage devices. There is presently no alternative to this device since there are few remaining sites in this Region for large reservoirs and the conventional hydroelectric power plants that can accompany them -- except in Areas 1 and 21 -- and because the alternatives such as gas turbines are very expensive. Where Environmental Quality is to be emphasized, extreme care must be taken and high costs endured when siting the pumped-storage facilities because of the lack of alternatives.

Benefits. Benefits are products of devices that, under the mixed objective, are helpful in fulfilling program needs. These benefits include monetary and non-monetary products and were found and described as three types: (1) those benefits that were a result of the first investments -- that is, benefits as the useful products of the devices; (2) those benefits that were a result of positive interactions between the devices -- that is, benefits as an increase in the useful products of the devices because of the interactions between the devices (reinforcement or synergism); and (3) those benefits that were a result of having chosen between alternative devices -- that is, benefits as savings gained by choosing the cheapest device or mix of devices. These three types of benefits may occur in various and complex combinations which may or may not be additive. No figures are available at this planning level for any of these benefits.

The largest and most important benefits for each need of the Areas are described first. This is an appraisal of benefits that depend upon the relative amount and importance of each product that is considered useful under the mixed objective to the fulfillment of the Area's needs.

Differences in the location and timing of benefits are explained for the larger and more important needs. Reasons are also given why the larger and more important products are considered as beneficial to the Area.

Some benefits will also be realized outside of an Area's water resources management system as defined in the NAR Study. The more important of these benefits are described and may include: total and average personal income changes or income distribution changes within an Area; distribution of regional electric power or recreation; and distribution of locally desirable industries.

Costs. Costs are investments for devices and products of devices that, under the mixed objective, are considered as hindrances in fulfilling program needs. These costs include monetary and non-monetary costs that were found to occur in three ways: (1) costs that were a result of investments and operation and maintenance; (2) costs that were a result of negative interactions (conflicts) between the devices -- that is, costs as a decrease in useful products; and (3) costs that were a result of having chosen between alternative devices -- that is, costs as losses incurred by not choosing the cheapest device or mix of devices.

These three types of costs may also occur in various, complex combinations and may or may not be additive depending on the situation.

Figures are available in the Area Programs for estimates of the first capital monetary investments for most devices. No figures are available for non-monetary costs and for most maintenance costs. The costs for water quality are very rough figures due to the lack of definitive information on particular devices and possible implementation programs.

The largest and most important costs of each need are described first. This appraisal depends upon the relative amount and importance of each cost from investment, product and choice that is sustained under the chosen mixed objective and for devices in the fulfillment of the Area's needs. Location and timing differences between the costs are described for large and important needs.

The reasons behind the appraisals of the larger and more important costs are almost always given. The reasons for the less important and smallest costs are given when they are unusual or related to the specific Area. Costs are also described when they occur outside of the immediate Area's water resources system. The above examples under Benefits also serve for costs.

Program Decisions. Decisions on alternative needs and devices for each Area require information on the benefits and costs of these alternatives. Benefits and costs of the Area Programs, however, are not like those of the typical accounting system since benefit figures and non-monetary cost figures are missing. Decisions in this situation must be made with benefits and costs that are primarily subjective and descriptive. This means that accounting for net benefits reflects the thinking of people familiar with each Area.

So that the people's thoughts about net benefits can be as clear as possible, the benefits and costs were described in the Area Programs from all possible viewpoints. This is the purpose for describing benefits and costs in the Area Programs in the three ways in which they may be gained and incurred -- investments, interactions and choices between alternatives. This descriptive procedure, however, can easily lead to double counting. Costs or benefits may appear twice on their own sides of the ledger because they appear in more than one of the three categories and it is difficult to separate them out in verbal descriptions. The various work sheets used during Program Formulation were helpful in pointing out these duplications.

Alternative Programs. Highlights are presented in this section on changes in the needs, devices, benefits and costs that would most likely result from emphasizing alone each of the alternative objectives that could be emphasized in an Area. This information should help the reader more clearly understand the choices involved in decid-

ing upon each Area's mixed objective and in deciding for himself among the best levels of needs, the best types of devices and the most likely benefits and costs for any emphasized objective. The information about alternatives can then be used by the person to help create new mixed objectives and to create new combinations of needs and devices for alternative programs because of differing opinions on the quantity or on the value of benefits and costs.

Variations from the recommended programs are presented for each emphasized objective. The largest and most important changes are given first and then any important changes in timing or location are described. Reasons for the large and important changes are also described. These Alternative Programs were not considered as a whole by the Plan Formulation Work Groups so that they can not be considered as complete and integrated plans in the same manner as the Area Programs.

NOTES FOR TABLES
OF ALL AREA PROGRAMS

1. The following notations are used in the tables:

blank	-	no application in this Area
x	-	application but no figures available
o	-	a value of zero

2. Need abbreviations used in the Device Tables include the following:

Publicly Supplied Water	PS
Industrial Self-supplied Water	Ind
Rural Water Supply	Rur
Irrigation Water	Irrig
Power Plant Cooling	Pow
Hydroelectric Power Generation	HPG
Navigation	Nav
Water Recreation	Rec
Fish and Wildlife	FW
Water Quality Maintenance	WQ
Flood Damage Reduction	FDR
Drainage Control	Drn
Erosion Control	Ern
Health	Hlth
Visual and Cultural Environment	VC

3. Major tributaries are included in all mainstream figures that are under Flood Damage Reduction of the Needs Tables; Flood Plain Management and Waterway Management of the Devices Tables; and Flood Damage Reduction of the Cost Tables.

4. All figures in the Needs Tables are gross; that is, each target year figure includes all previous needs. The figures of the Device and Cost Tables show only increments for eacy target year.

5. Figures for base years of Water Recreation in the Needs Tables are included in the first target year figure.

6. Power Plant Cooling costs are almost all privately incurred. Those costs shown in the Cost Tables are additional expenses beyond those necessary for the National Income objective.

7. Mainstream Flood Damage Reduction needs, because of the expenses that would be involved, are not completely fulfilled in any Area.

CHAPTER 3
COMPARISON OF AREA PROGRAMS WITH MORE DETAILED BASIN STUDIES

The purpose of framework planning is to assess the magnitude of needs, recommend devices to fulfill these needs and determine the general level of these devices all on a broad regional basis. Framework plans, to serve their purpose, must include consistent assumptions between major geographical, social and economic areas so that comparisons can be made between areas and priorities can be established. Comprehensive basin studies should lead to the development of a plan, detailed enough for implementation and, therefore, must be specific in details of sites and device sizes and need magnitudes that are being fulfilled.

Differences between the NAR Study results and the results of comprehensive basin studies that have concerned areas within the NAR are based on differences in the two specific sets of conditions typifying the methods used in the two types of studies. The NAR results are based on nationally consistent demographic and economic assumptions and on broad methodologies that are applicable over the entire North Atlantic Region. Basin studies utilize demographic and economic assumptions and apply methods that are site specific and strongly influenced by judgement based on local knowledge. The findings of basin studies, particularly in relation to the early action programs, include the realism of local knowledge and detailed information.

Recommendation number two of the NAR Report, Chapter 10, was addressed to the differences between these two types of studies. Where there are differences between the NAR Study results and the results of recently completed or continuing basin studies in the NAR, these plans rather than the NAR Area Programs should be the guide for development.

Areas in the NAR where comprehensive basin studies are current include the Connecticut River Basin, the Susquehanna River Basin, the Deleware River Basin and, to a lesser extent, the Potomac River Basin. The remainder of this Chapter contains two examples of the differences between framework and basin studies using the Susquehanna River Basin and the Deleware River Basin as the illustrations.

Demographic and economic projections are the basic differences in the results of the comprehensive plan for the Susquehanna River Basin and the NAR Program for Area 17. The NAR projections for Area 17 are based on a population growth rate of about 1.1 percent per year. The Susquehanna Study assumes a rate of 1.7 percent per year. In addition, there are significant differences in the assumptions of industrial growth. The following table shows some of these differences in assumptions.

	NAR Study			Susquehanna Study		
	1980	2000	2020	1980	2000	2020
			(thousands)			
Population	3,403	4,902	6,097	4,655	6,736	9,528
Employment	1,543	1,949	2,406	1,685	2,543	3,784
Employment in Manufacturing	530	615	713	485	538	595

These projection differences together with different technologic assumptions are reflected in the fresh water demands shown in the next table.

	NAR Study			Susquehanna Study		
	1980	2000	2020	1980	2000	2020
		(million gallons per day)				
Publicly Supplied Water	449	693	1,104	449	765	1,368
Rural Water Supply	55	71	65	92	158	240
Industrial Water Supply	603	1,189	2,150	483	748	1,084
Power Plant Cooling	170	290	470	129	349	821
Total	1,277	2,243	3,789	1,253	2,020	3,513

The projected totals for these four needs agree closely in the above table. The assumption differences for the two studies are reflected in the higher figures in the Susquehanna Study for Publicly Supplied Water and Rural Water Supply. The differences are due to the higher population projections. The higher Industrial Water Supply figures in the NAR Study are due to the much larger manufacturing employment level projected for NAR Area 17. The higher Power Plant Cooling figures for the Susquehanna Study are due to the assumptions of different levels of use of cooling towers versus instream cooling.

These differences in water demand for the two studies affect, in turn, the storage in the basin that is considered to be necessary by each study. Storage requirements for 1980 in the Susquehanna Study are higher than that of the NAR Study. The Susquehanna Study assigns specific storage to recreation, fish and wildlife and water quality needs. On the other hand, the year 2020 increment of storage recommended in the NAR Study is larger because no reduction in outflow from the basin into the Chesapeake Bay was permitted under the flow regulation procedures considered in the NAR Study while the Susquehanna Study permits such reductions.

Differences in storage requirements appear in the results of the Delaware River Basin Study and the NAR Study (Area 15). These storage differences occur especially in the first two planning periods, 1980 and 2000, as shown in the following table and are based more on differences in the assumptions about technology and

when devices are in use rather than on differences in economic and population projections.

	NAR Study			Delaware Study		
	1980	2000	2020	1980	2000	2020
	(thousand acre feet)					
Conservation Storage	48	188	1,079	750	935	1,370

Tocks Island and Beltzville Reservoirs are assumed to be presently in operation in the NAR Study while they are not assumed to be in operation in the Delaware Study until 1980. The NAR Study also assumes lower gross withdrawals of water from the Delaware River than the Delaware Study does because of larger industrial reuse of water in the two early planning periods. Water losses in the NAR Study are also handled differently and are assumed not to be made up unless it is necessary in order to maintain instream and outflow level constraints. These constraints are based mostly on a regional analysis and not tailored to the specific basins, with some exceptions.

Assumptions on water exports from the Delaware River Basin differ for the two studies. Exports to the Hudson River Basin (Area 12) from the Delaware are assumed in the NAR Study to be 540 mgd. This is the maximum that could be exported under criteria of the framework study while maintaining 1,750 cfs at Montague on the Delaware River. The Delaware River Basin Study assumes 800 mgd to be exported to the Hudson. If the NAR Study used 800 mgd for export and still maintained 1,750 cfs at Montague, storage requirements in the Delaware River Basin would probably be about 200,000 AF higher.

Lastly, the NAR Study uses yield storage figures that are based on synthetically derived streamflows and shortage index criteria. Less storage is required under this method than under the procedures of the Delaware River Basin Study that use the drought of record criteria.

The storage requirements for the Delaware River Basin in the two studies do become fairly close in the final -- 2020 -- planning period. The NAR Study results show greater storage requirements for that period than those of the Delaware Study (considering that Tocks Island and Beltzville Reservoirs are already included) because the projected water withdrawals and losses catch up with those projected in the Delaware Study.

Differences similar to those above occur among other needs and other devices of the comprehensive basin studies and the NAR Study. These differences point up the adjustments that must be made when moving from a framework study to river basin studies.

NOTES FOR TABLES
OF ALL AREA PROGRAMS

1. The following notations are used in the tables:

blank	-	no application in this area
✓	-	application but no figures available
o	-	a value of zero

2. Need abbreviations used in the Device Tables include the following:

Publicly Supplied Water	PS
Industrial Self-supplied Water	Ind
Rural Water Supply	Rur
Irrigation Water	Irrig
Power Plant Cooling	Pow
Hydroelectric Power Generation	HPG
Navigation	Nav
Water Recreation	Rec
Fish and Wildlife	FW
Water Quality Maintenance	WQ
Flood Damage Reduction	FDR
Drainage Control	Drn
Erosion Control	Ern
Health	Hlth
Visual and Cultural	VC

3. Major tributaries are included in all mainstream figures that are under Flood Damage Reduction Needs of Table 1, Flood Plain Management and Waterway Management Devices of Table 2 and Flood Damage Reduction Costs of Table 3.

4. All figures in the Needs Table 1 are gross; that is, each target year figure includes all previous needs. The Devices and Costs figures of Tables 3 and 4 show only increments for each target year.

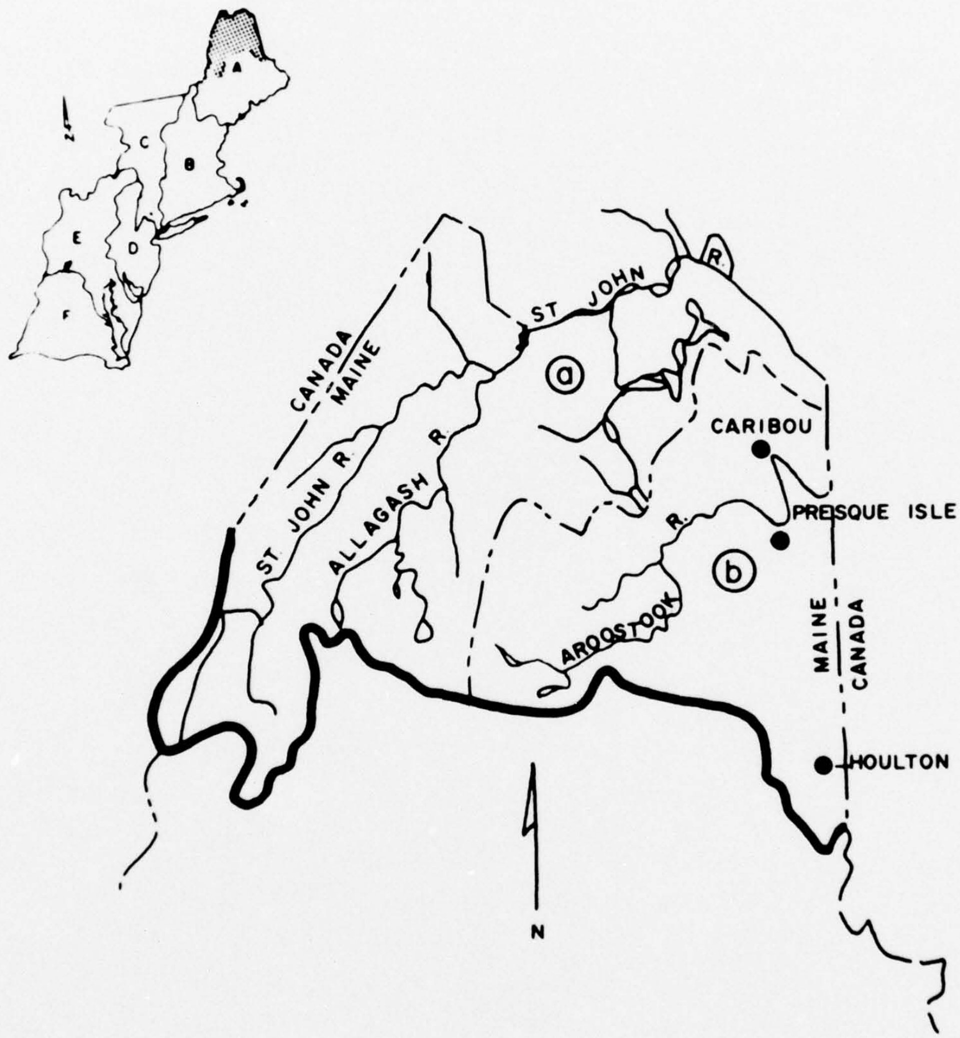
5. Figures for base years of water recreation needs in Table 1 are included in the first target year figure.

6. Power plant cooling costs are almost all privately incurred. Those costs shown in Table 3 are additional expenses beyond those necessary for the National Income objective.

7. Mainstream Flood Damage Reduction needs, because of the expenses that would be involved, are not completely fulfilled in any Area.

CHAPTER 4
AREA PROGRAMS

AREA I ST. JOHN RIVER BASIN



Area 1

St. John River Basin. Area 1 consists of the portion of the St. John River Basin that lies within the United States. Located wholly within the State of Maine, the 7,360 square mile Area represents one third of the total St. John Basin and is bounded on the north, east and west by the portions that lie within Canada. The Basin's drainage outlet is through Canada to the Bay of Fundy. Sub-area a is drained by the mainstem of the St. John River and has moderately rugged, densely forested terrain with numerous lakes. Sub-area b is drained by the Aroostook and other rivers that flow into the St. John through Canada. The Area's topography is rolling terrain extensively developed for agriculture.

Area 1 is primarily forest-wildland with some farm landscape. The majority of the Area is of medial visual quality with less than one percent high quality. It contains the Allagash Wilderness Waterway and the only remaining large wilderness area in the N.A.R.

The 1960 population was 106,064 with a population density of 14 per square mile. Sub-area a contained 26,470, or six people per square mile, and sub-area b contained 79,594, or 25 per square mile. The total population is expected to increase 52% to 161,400 by 2020.

The industries with the largest 1960 employment in the Area are wholesale and retail trade; services; agriculture, forestry and fisheries; and public administration. Employment is expected to increase in all industries except for agriculture, forestry and fisheries.

Total employment is expected to increase 79% from 34,642 in 1960 to 61,900 by 2020, and per capita income should increase from 37% below the national average in 1959 to 32% below in 2020. Unemployment, presently at about 10%, and poverty are major problems in most of the Area.

Water is very abundant in the Area and very few structures exist to control surface waters. Paper and food products are expected to continue as the largest water using industries. Pollution is a problem on the mainstem as a result of the paper and food processing industries, and is also a problem on the Prestile Stream and the Aroostook River primarily from the food processing industry alone.

Average annual runoff in Area 1, including drainage from about 4,100 square miles of contributing area in Canada, is approximately 12,115 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,220 m.g.d. and the corresponding seven-day minimum is about 68% of this total, or 824 m.g.d. (See Appendix C). The addition of 4 m.g.d. as

an allowance for consumptive losses results in an existing firm resource available for use of about 828 m.g.d., or 7% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 3,980 m.g.d., or 33% of the average runoff. Considering the U.S. portion only, the practical limit would be equivalent to almost 47% of the average runoff. Potential sources which would develop the increase of 3,152 m.g.d., include major storage, accounting for 79% of the increase; upstream storage, 8%, and ground water development, 13%.

Possible Alternative Planning Objectives. Sub-areas a and b vary considerably in population and development, but are not so dissimilar that a separate mixed objective should necessarily be considered for each. Any combination of the three objectives can be emphasized in planning the management of the Area's water and related resources.

Recommended Mixed Objective. It is recommended that Area 1's planning objective equally emphasize Regional Development and Environmental Quality. The program of water resources management should preserve the Area's extensive scenic and recreational resources, especially in sub-area a, by limiting their economic development and maintaining their quality. This preservation should be done in such a way, however, to allow the increasing needs of industry to be met, especially in sub-area b where it is being encouraged to grow. This objective combination is aimed to protect and in some ways improve this Area's extensive wildlands while helping to stimulate industrial growth. The industrial growth and increased levels of recreation should help raise the Area's low income, decreasing the unemployment and poverty.

Needs To Be Satisfied. The needs considered most important for attaining the Area's mixed objective are fish and wildlife, water recreation, recreational boating, publicly supplied water, agriculture irrigation and industrial self-supplied water. All of these needs will have steady growth rates during the planning period except for industrial self-supplied water and agriculture irrigation which have very rapid ra s of growth.

There are other large needs, however, which will be keys to the achievement of those considered to be most important. These other needs will have steady growth rates. They include water quality maintenance that will be key to all of the important needs and visual and cultural needs that will be key to water recreation and fish and wildlife needs.

Preservation and maintenance of unique landscapes will be necessary for meeting the visual and cultural needs. Provisions

of such landscapes depends upon the retention and extension of the Area's unique wilderness and wild streams. There are rapidly increasing needs for agricultural irrigation water and for agricultural erosion control. Satisfaction of these needs will keep agricultural lands economically competitive with agricultural lands of nearby areas.

Meeting the Area's water quality maintenance needs will be of particular importance to the industrial self-supplied and publicly supplied water needs in the lower reaches of the St. John and Aroostook Rivers. Meeting these needs in the rest of the Area will be of great importance to water recreation, fish and wildlife and visual and cultural needs. The needs must be met, however, in a way that will not interfere with the attraction of new industry nor with the growth of present industries.

Power plant cooling and hydroelectric power generation needs will become relatively large during the later years of the planning period due to the growth of the paper industry and to the increase in exportation of power from the Area.

The health needs of the Area, primarily mosquito and black fly control, must be met to help insure fulfillment of recreation needs that are often obstructed by the presence of these pests.

Other needs of Area 1 which will have steady growth rates but will not be key to the attainment of the mixed objective are rural water supply and cropland drainage control.

There is a legal need in this Area to be able to review designs for large construction projects and influence their visual and cultural inpacts.

Devices. Water quality control and land management are the most important devices in Area 1. The increasing use of quality control devices matches the growth of the withdrawal needs throughout the planning period. Land acquisition for visual and cultural needs should occur mainly in the early planning period to insure that development of wilderness areas can be halted and that it can be done at a low cost. If advanced waste treatment is not in extensive use by 2000, meeting the liquid waste standards will require storage for low flow augmentation.

Publicly supplied and industrial self-supplied water needs can be met without the use of structural control of surface waters for the planning period as long as water quality standards are met. Contrarily, fulfillment of hydroelectric power generation and water quality maintenance needs all require a mainstream reservoir by 2000. This Area has the only reservoir storage site in the NAR which combines a large capacity for in-stream power generation with a large amount of permanent storage for other needs. Agri-

culture irrigation water and upstream flood damage reduction needs can be fulfilled by upstream reservoirs.

The use of some Water/Land devices will be necessary over the whole planning period. These devices can easily meet the needs of drainage and erosion control and partially meet the needs of visual and cultural and fish and wildlife. Early erosion protection will be necessary on the Area's eroded urban and agricultural lands to help meet the needs of visual and cultural and fish and wildlife and to add to the efficiency of the agriculture and forestry industries. Flood plain management may be 20% effective on the mainstem for flood damage reduction and probably less effective upstream necessitating increases in storage by 1980 and again by 2020.

Insect control, while important, will probably be difficult in the Area because of the magnitude and complexity of the problem and the present lack of knowledge and local commitment.

Devices to fulfill fish and wildlife needs, if water quality maintenance needs are fulfilled, will consist primarily of maintenance of existing habitat along with provision of increased access and fishways. The fishways can be augmented by removing several obsolete water control structures, such as hydroelectric power and industrial mill ponds, that interfere with the movement of anadromous fish.

Research will be necessary to insure the capability of meeting water quality standards from 1980 to 2000 while the paper and the food processing industries continue to grow.

Small sized power generation facilities are presently in use in the Area because of the small and dispersed demands for power. The use of non-condensing generation will be needed in the last two planning periods to meet the Area's power demands and reduce the conflicts that would otherwise result between the water using devices for Regional Development power needs and the preservation of wilderness for Environmental Quality. Special efforts will be necessary to resolve the environmental problems involved with the siting of the power plant cooling devices that will be needed.

The International Joint Commission of the United States and Canada should have its present powers - over boundary water disputes and studies - strengthened to ensure mutually acceptable development and more efficient utilization of water in the St. John River Basin.

<u>Benefits</u>. Benefits will be very high from meeting water quality standards of Area 1 particularly increasing the multiple-uses of water at reduced costs. These uses include: increased downstream withdrawal, higher quality visual and cultural experience, greater surface area for water recreation and improved fish and wildlife habitat.

Economic benefits will be realized by providing certain services necessary for the Area's growing industries. These services include the fulfillment of the following needs: power plant cooling, hydroelectric power generation, non-agricultural irrigation water, recreational boating, flood damage reduction and drainage control. Benefits to the environmental quality aspects of the mixed objective will be provided by fulfillment of the agricultural irrigation water, erosion control, visual and cultural and health needs.

A large multiple purpose storage project in the Area by 2000 will reduce the initial capital investment that would be necessary for the individual needs of water quality maintenance, hydroelectric power generation, irrigation water, recreational boating, water recreation and visual and cultural.

Costs. Water quality maintenance costs are by far the largest over the entire planning period because of the difficulty in treating the various types of wastes - especially paper wastes. Water recreation and visual and cultural costs will also be fairly large in the first planning period, but both will decline in the later periods. The visual and cultural costs, however, could become much greater if these needs are not met as planned during the first period.

Hydroelectric power generation investments will be high between 1980 and 2000 because of one large storage project. Water recreation benefits from the large reservoir will be somewhat reduced by water level fluctuations for hydroelectric power generation. This loss may be minimal because of the reservoir's size. Visual and cultural benefits will be decreased by the presence of transmission lines and costs may have to be increased to blend these lines into the environment.

Costs may increase to ensure that the combined EQ and RD mixed objective is achieved. More expensive non-condensing power facilities are used later in the planning period to reduce the need for power plant cooling water. Power plant cooling costs will still increase, however, as special environmental studies are made for careful siting of power plants.

Investments in wells for rural water supply will decline after 2000 as many of the new rural needs will be fulfilled by central systems. Capital investments are very low throughout the planning period for meeting the needs of publicly supplied water, industrial self-supplied water, rural water supply, non-agricultural irrigation, fish and wildlife, flood damage reduction and drainage control. Erosion control costs will be moderate in the first planning period but decline from then on as the needs are met.

Drainage control benefits will decrease as drainage practices are not applied to some agriculture lands for protection of fish

and wildlife. Setting aside of wilderness and near wild areas will result in higher costs due to stricter management of local timber cutting.

An agreement with Canada on liquid waste standards would probably raise water quality maintenance costs so that wastes would not continue to be passed on to downstream water users.

Alternative Programs. Emphasizing National Income would reduce the needs, devices and costs oriented towards Environmental Quality particularly in connection with water quality maintenance, water recreation, fish and wildlife, erosion control and drainage control. Insect control would probably not be stressed as a device to fulfill the health and recreation needs. Liquid waste disposal devices for meeting water quality standards would not include nutrient control, stormwater discharge control and separation of combined sewers which primarily benefit Environmental Quality. Power plant cooling water needs would increase but energy production costs would be reduced by omitting some use of non-condensing devices later in the planning period.

Regional Development could be emphasized by orienting needs and devices towards development of the type of local economic activity which can more directly and continuously aid the Area's income. Less investment would be placed in meeting seasonal needs for water recreation and fish and wildlife. Minimum water quality maintenance needs in the upper reaches would still be met to allow as much intensive water recreation development as possible. Irrigation water needs would be increased to raise the Area's agriculture income. Commercial navigation investments could be increased although the effects would be minimal. Fewer devices would be used for water quality maintenance, especially those for environmental quality. Drainage control needs would be extensively raised to increase the efficiency of forestry. Erosion control needs would remain essentially at the same level, except for a decrease in the small streambank erosion control needs that provide environmental quality benefits unnecessary to this objective. Public health needs would be raised as insects hinder recreational use of the Area.

Emphasizing Environmental Quality would cause the fewest changes in the recommended program. Achievement of an environmental quality emphasis requires a minimum of income, transportation and access so that people are able to enjoy the environment around them. Regional Development should not be forgotten if Environmental Quality is emphasized in Area 1 so that local people can attain mini-

mum living standards. Agriculture irrigation needs would be set at a higher level to attain Regional Development and Environmental Quality objectives. Power cooling needs would be lowered considerably but the Environmental Quality devices would be emphasized and cost would greatly increase. Larger investments could be made in water recreation needs to gain high quality experiences. Less upstream storage and more flood plain management could be used to achieve the same flood damage reduction at less disturbance to the environment.

AREA 1

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	6	8	11	17
Industrial Self-Supplied Water (mgd)	20	40	80	150
Rural Water Supply (mgd)	3.9	5.3	7.2	7.6
Irrigation Water: agriculture (1000 afy)	0.1	21	40	73
non-agriculture (1000 afy)	0	0.5	1.0	1.4
Power Plant Cooling: withdrawal, saline (cfs)				
brackish (cfs)				
fresh (cfs)	20	0	500	550
consumption, brackish (cfs)				
fresh (cfs)	0	0	4	34
Hydroelectric Power Generation (mw)	2	0	800	1300
Navigation: commercial (m.tons annually)	0	0	0	0
recreational boating (1000 boats)	9	10	16	23
Water Recreation: visitor days (m.)	x	2.4	3.7	5.2
stream or river (miles)	x	28	35	48
water surface (1000 acres)	x	7.5	10.8	14.0
beach (acres)	x	76	94	106
pool (m. sq. ft.)	x	1.3	1.6	1.8
land facilities (1000 acres)	x	4.2	5.4	6.5
Fish & Wildlife: sport fishing man-days (m.)	0.75	0.85	0.99	1.17
surface area, lake (acres)				
stream (acres)				
access, fresh (acres)	x	0	21	46
salt (acres)				
anadromous (acres)	x	4	6	7
piers (1000 feet)				
hunting man-days (m.)	0.33	0.40	0.47	0.54
access (1000 sq. mi.)	x	0	0.11	0.33
nature study man-days (m.)	0.14	0.16	0.18	0.22
access (1000 acres)				
Water Quality Maint.: non-industrial (m. PEs)	0.11	0.12	0.14	0.16
industrial (m. PEs)	2.1	4.5	8.8	16.6
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	0.06	0.10	0.17	0.34
mainstream (m.$)	0.17	0.26	0.48	0.98
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	11	17	28	47
forest land (1000 acres)	x	0	7	29
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	180	240	270	280
urban (1000 acres)	39	47	57	71
stream bank (mi.)	x	1	4	7
coastal shoreline (mi.)				
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	400	6400	6400	6400
unique shoreline (mi.)				
high quality (sq.mi.)				
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	7	10	14	8	11	17	8	11	17
	40	70	120	40	70	130	40	70	150
				5.3	7.2	7.6			
	38	103	136	21	40	73	38	113	145
	0.5	1.0	1.4	0.5	1.0	1.4	0.5	1.0	1.4
	20	0	0	20	0	3000	20	280	1850
	0	0	0	1	0	28	1	3	41
				0	800	1300			
	0	0	0	0	0	0	0	0.6	1.0
				10	16	23			
	2.4	3.7	5.2	2.1	3.2	2.8	2.5	3.8	5.3
	28	35	48	9	11	16	14	17	24
	7.5	10.8	14.0	2.1	3.0	3.9	4.0	5.9	7.6
	76	94	106	21	26	33	59	74	80
	1.3	1.6	1.8	0.4	0.5	0.6	1.0	1.3	1.4
	4.2	5.4	6.5	0.8	1.0	1.3	1.5	1.9	2.2
				0.72	0.90	1.06			
				0	19	42			
				4	5	6			
				0.34	0.39	0.45			
				0	0.10	0.30			
				0.14	0.17	0.20			
				0.12	0.14	0.16			
				4.5	8.8	16.6			
				0.10	0.17	0.34			
				0.26	0.48	0.98			
	17	28	47	15	24	40	17	28	47
	0	14	57	0	14	57	14	57	187
	240	270	280	230	260	260	240	270	280
	47	57	71	40	43	47	47	57	71
	1	4	7	0	1	2	1	2	3
	x	x	x	x	x	x	x	x	x
	6400	6400	6400	6400	6400	6400	Same as EQ		

AREA 1

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)		28*	19*	0*
mainstream (1000 af)	WQ	13*	33*	63*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	20	40	69
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		17*	17*	26*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow			x
chemical/biological				
potable water treat plants (mgd)	PS	1.0	3.0	5.6
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	3.9	0	0
secondary (90%) (m. PE removed)	WQ	0	8	15
advanced (95%) (m. PE removed)	WQ	0	0.44	0.84
effluent irrigation				
nutrient control	WQ	x	x	x
stormwater discharge control	WQ	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ	x	x	x
Pumped Storage	HPG		x	
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	1	1	0
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	1	0	2
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn	40	x	30
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

ϕ Flood control storage not included.

** Also includes the following purposes: PS, Ind, Irrig

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	29	49	25	Irrig	15	15	25	Irrig	29	56	24
WQ		x	x	WQ		x	x	WQ		x	x
Pow**	18	34	46	Pow**	18	37	60	Pow**	20	40	69
Rur**	11	19	12	Rur**	8	9	13	Rur**	12	22	13
								Pow			x
PS	0.5	3.0	3.8	PS	1.0	3.0	5.6	PS	1.0	3.0	5.6
				WQ	3.9	0	0				
				WQ	0	8	15				
				WQ	0	0.44	0.84				
WQ	x	x	x								
WQ	x	x	x								
WQ	x	x	x								
				HPG		x					
FDR,VC	2	23	5	FDR,VC	1	1	0	FDR,VC	1	1	0
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	0	0	0	FDR	1	0	2	FDR	1	0	2
FDR,Drn	420	840	840	FDR,Drn	40	x	30	FDR,Drn	40	x	30
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern		x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 1

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	4800	0	0
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)				
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC,FW	1200	0	0
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	x	x	x
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility				
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x		
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish				
wildlife				
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth, Rec	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)	Pow		x	x
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	FW	x	x	x
change project design load				
V. Others				
Upstream Flood Control Storage (1000af)	FDR	8	0	16
Flood Skimming	Ind	x	x	x
Hydroelectric Generation Storage	HPG		x	

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	4800	0	0	VC, FW	4800	0	0	Same	as	EQ	
VC, FW	1200	0	0	VC, FW	1200	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x			VC	x			Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
Pow			x								
				FW	x	x	x				
FDR	0	0	0	FDR	8	0	16	FDR	8	0	16
HPG		x		HPG		x		HPG		x	

AREA 1

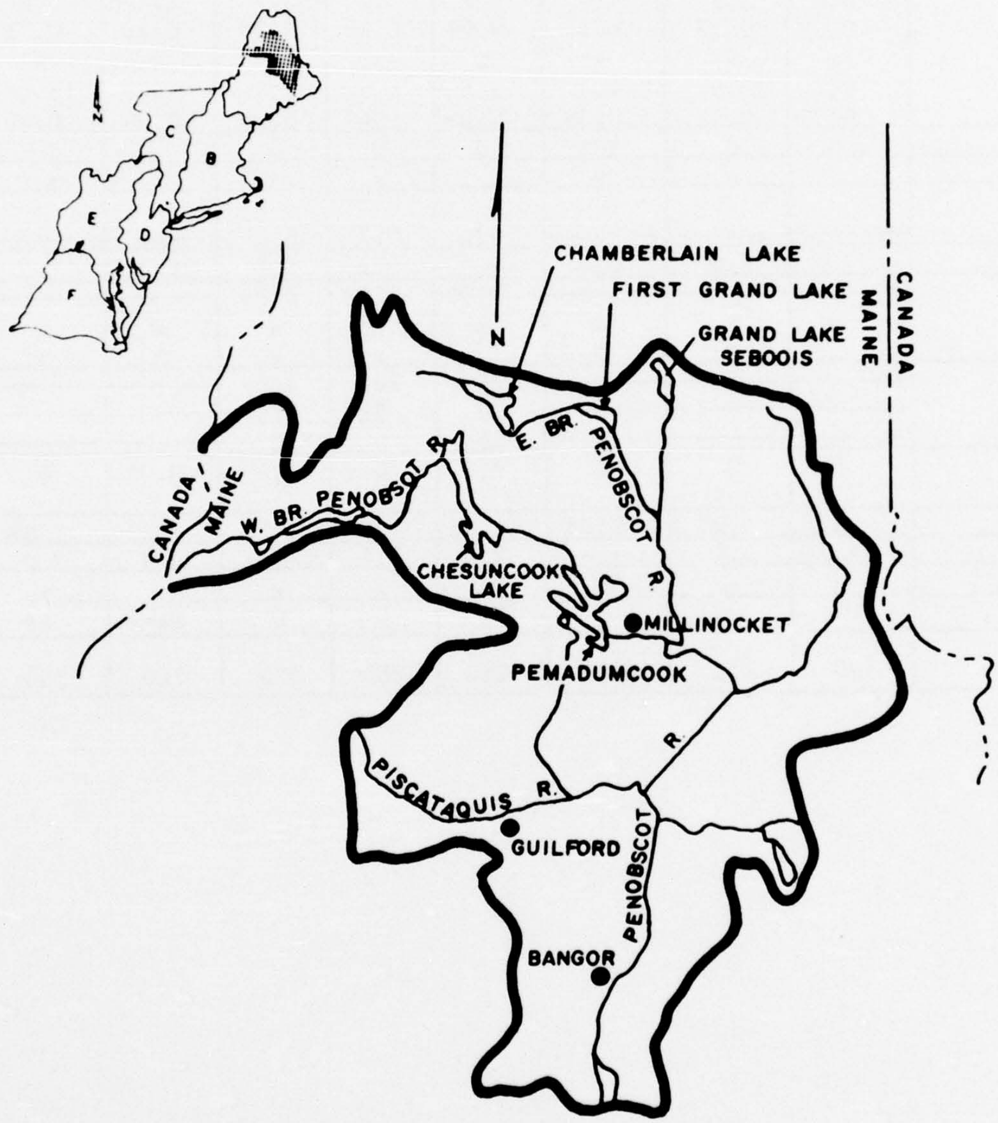
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	3.1*	2.3*	0*	
mainstream	6.8*	9.5*	16.1*	
wells	9.1*	9.5*	13.8*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	1.2	3.7	5.9	
industrial self-supplied water	0.10	0.21	0.35	
rural water supply	x	x	x	
irrigation, agriculture	5.8	6.5	9.7	
nonagriculture	0.39	0.42	0.39	
Power Plant Cooling Water	0	2	16	
Hydroelectric Power Generation		x	x	
Navigation: commercial				
recreation	0.1	0.2	0.2	
Water Recreation	28.1	7.5	18.5	
Fish and Wildlife: fishing	0.06	0.26	0.32	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	79	168	315	
advanced	0	91	173	
other †	14	0	0	
Flood Damage Reduction: upstream	0.7	0	1.4	
mainstream				
Drainage Control	0.20	0.48	1.00	
Erosion Control	4.1	3.4	1.7	
Health	x	x	x	
Visual and Cultural	22	0	0	
Summation of Available Estimated Costs	170	300	570	

*From the supply model and includes OMR costs.

† Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	2.5	4.9	2.5	1.5	1.7	2.6	2.5	4.9	2.5
	0.9	1.9	1.1	0.7	0.8	1.1	1.0	1.9	1.1
	0.6	3.7	4.4	1.2	3.7	5.9	1.2	3.7	5.9
	0.09	0.17	0.24	0.09	0.19	0.30	0.10	0.21	0.35
	x	x	x	x	x	x	x	x	x
	9.2	18.6	9.7	5.8	6.5	9.7	9.2	18.6	9.5
	0.39	0.42	0.39	0.39	0.42	0.39	0.39	0.42	0.39
	0	0	100	0	0	0	0	2	25
		x	x		x	x		x	x
				0.1	0.2	0.2			
	37.5	9.8	6.0	9.3	3.1	8.2	28.1	7.5	18.5
				0.06	0.23	0.29			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				79	168	315			
				0	91	173			
				14	0	0			
	0	0	0	0.7	0	1.4	0.7	0	1.4
	.20	.60	1.35	.13	.53	1.25	.43	1.08	2.80
	4.1	3.4	1.7	2.8	2.4	1.0	4.1	3.2	1.7
	x	x	x	x	x	x	x	x	x
	22	0	0	22	0	0	same	as	EQ
	170	300	620	140	280	520	160	300	560

AREA 2 PENOBSCOT RIVER BASIN



AREA 2

Penobscot River Basin. Area 2 encompasses the portion of Maine drained by the Penobscot River. The Area covers 8,525 square miles and is dominated by rolling terrain with a scattering of isolated mountain peaks in the North and wide flat valleys in the South.

The predominant landscape form is rolling hills with some mountains and steep hills. More than three-quarters of the land-use pattern is forest-wildland with the remainder in forest-town units. Less than one percent is farmland. Nearly three-fourths of the Area consists of high visual quality and the remainder is medial. There are two preserved areas -- the Allagash Wilderness and Baxter State Park.

The infertile stony soil and the severe climate limited agriculture for the early settlers. Fishing, lumbering, fur trading and shipbuilding consequently developed rapidly. Forestry is still an important industry in the Area.

The Area's 1960 population was 143,725 with over a quarter of the people living around Bangor. The population density was 17 people per square mile. The projected population for 2020 is 219,000.

Per capita income was 80 percent of the national average in 1959, and is projected to increase to 86 percent of the national average by 2020.

The 1960 employment of 50,090 is expected to increase to 88,800 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; paper and allied products; and transportation communication and public utilities. Employment is expected to increase in all industries except for agriculture, forestry and fisheries.

Water is very abundant in the Area and runoff is regulated considerably by existing lakes and ponds. Present storage amounts to about 1.7 million acre-feet, most of which was developed for power and log driving. Water quality problems exist from discharges of industrial and non-industrial wastes on the Penobscot River below Millinocket and on the Piscataquis River below Guilford.

Average annual runoff in Area 2 is approximately 9,650 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 3,220 m.g.d. and the corresponding seven-day minimum is about 80% of this total, or 2,560 m.g.d. (See Appendix C). The addition of 8 m.g.d. as an allowance for consumptive losses, results in an existing firm resource available for use of 2,568 m.g.d., about 27% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 5,814 m.g.d., or 60% of the average runoff. Potential sources which would develop the increase of 3,246 m.g.d., include major storage, accounting for 71% of the increase; upstream storage, 16%, and ground water development, 13%.

Possible Alternative Planning Objectives. Area 2 has a fairly uniform terrain and the only significant concentration of people and industry is around Bangor. There is an abundance of water and other recreational resources in the Area. Almost any combination of the NAR planning objectives can be emphasized. It is doubtful, however, if any one of the objectives alone would suffice. Environmental Quality should receive at least some attention to maintain the Area's wilderness resources.

Recommended Mixed Objective. It is recommended that equal emphasis be placed on Environmental Quality and National Income for the mixed objective of Area 2. This objective mix, because of the Area's abundant environmental resources and low population, will enable the growing recreation and urban needs to be met with a minimum of conflict. The forest-wildland character of the Area can be preserved through a continuation of the forest management practices presently in use for recreation that should not conflict with the timber industry at its present rate of development. Increased industrial and urban development should help raise the income of the Area with little danger to the environment.

Needs to be Satisfied. The primary consideration in meeting the recommended mixed objective is to place as much emphasis on Environmental Quality as is possible while still allowing National Income to be achieved. The important needs in this program are water recreation, visual and cultural, water quality maintenance and industrial self-supplied water.

The water recreation, fish and wildlife, and visual and cultural needs are heavily dependent on fulfillment of the key and rapidly growing water quality maintenance needs. Only if these needs are met can the Environmental Quality objective be attained. These water quality maintenance needs are very large on a per capita basis and are located primarily in the southern quarter of the Area where the major cities and industries are concentrated. These Environmental Quality related needs will complete Regional Development aspirations especially as they aid the income potential of recreation and tourist supported industries.

The industrial self-supplied water need will be large and will grow rapidly, doubling each planning period. This is true even though the major industry, paper and allied products, is projected to double its water use efficiency by 2020. The needs for power plant

cooling and agriculture irrigation water will grow rapidly as they increase several fold. Flood damage reduction, drainage and erosion control, navigation, fish and wildlife and visual and cultural needs will increase steadily with population. Public supplied water needs, although very small, will have a very large growth rate. Rural water supply needs will remain relatively constant over the planning period. Fish and wildlife needs are heavily dependent upon attaining the access for anadromous fishing. The growth rate of hydroelectric power generation will be very large in the last time period as it meets regional needs.

Devices. Direct river withdrawals will satisfy the larger water needs, especially self-supplied industrial and power plant cooling, though cooling devices should be used in the later time frames to cut down on withdrawals to aid in attaining the Environmental Quality aspects of the mixed objective. Other facilities to be used include pumped storage, to meet the hydroelectric power generation needs in the last period, reservoir storage for low flow augmentation and appropriate treatment for water quality maintenance before the water is returned to the river for reuse. Wells will be utilized where possible when river access is a problem. Early and continued attention to proper Water/Land management devices will be required to meet most of the drainage and erosion control and flood damage reduction needs and some of the visual and cultural and fish and wildlife needs. Land and biological devices will be used to meet most of the two latter needs. These will be especially important in attaining access to anadromous fishing sites. Some upstream storage is required for flood damage reduction and mainstream storage for publicly supplied water and water quality maintenance needs. Interstate agreements will be required for satisfaction of the visual and cultural needs.

Benefits. The devices recommended for satisfying the Area's needs will also satisfy a portion of the water recreation and visual and cultural needs of surrounding Areas.

Benefits will be large from satisfying the withdrawal needs of industrial self-supplied water, power plant cooling and publicly supplied water. High benefits will also occur from satisfying water quality maintenance, water recreation, fish and wildlife and visual and cultural needs.

The highly beneficial multiple-use effects from satisfying the water recreation, visual and cultural, fish and wildlife, and water quality maintenance needs will significantly enhance the total benefits. Large benefits will be gained under the mixed objective by maintaining proper control of private timber management. This will allow fulfillment of visual and cultural needs while retaining the economic income from the Area's forest resources.

Satisfying flood damage reduction needs through flood plain management and erosion control needs through erosion protection also

produces large multiple use benefits, particularly with respect to visual and cultural, fish and wildlife and water recreation needs.

High monetary and non-monetary benefits will result from recreational investment because of the anticipated high need for recreation in this Area of abundant natural amenities. High benefits will also result from fish and wildlife development with restoration of anadromous salmon runs.

Costs. Water quality maintenance costs are the highest in the Area because of the degree of treatment desired and because of the wide distribution of waste sources. Water recreation costs are fairly high, particularly in 1980 when an initial boost in expenditures is required to satisfy existing needs. Navigation costs for improvements of channels, harbors and offshore facilities are fairly small. The cost of hydroelectric power generation becomes high in 2020 with the large increase in the use of pumped storage facilities for satisfying peaking power needs of the market.

The small costs for industrial self-supplied water, devices to meet esthetic needs of water recreation, visual and cultural, and fish and wildlife will be required throughout the planning period. Moderate costs for flood damage reduction will result from the use of insurance and land control devices.

Significant costs occur from devices which satisfy industrial self-supplied water needs interfering with the Environmental Quality related needs. Maximum attention should be given to reducing these costs while still meeting the National Efficiency portion of the recommended mixed objective.

Alternative Programs. If Environmental Quality were chosen to be primarily emphasized throughout Area 2, the greatest changes in the needs to be fulfilled would be for agricultural irrigation water, power plant cooling and navigation. Irrigation of agricultural land would be substantially increased through the addition of wells and river intakes. This will increase landscape quality and slow the anticipated decline in agriculture to preserve open space. Power generation facilities requiring cooling water would be diverted to other areas in the later planning periods to reduce thermal pollution. Some commercial navigation would also be diverted to other areas, as it is a major potential hazard to water quality in the tidal portion of the Area. Upstream flood damage reduction would be accomplished predominantly through flood plain and watershed management to preserve the visual landscape. Drainage of farm lands would be slightly increased to slow the decline of agriculture. This would improve the visual aspects of the vegetation and increase open agricultural space for landscape diversity. Slightly decreased needs for publicly supplied and industrial self-supplied water would occur.

If Regional Development were chosen to be emphasized throughout the Area, the recommended program would be changed to increase business opportunities and encourage above normal industrial expansion. Industrial self-supplied water, agriculture irrigation water, and drainage control needs would be increased while the manner in which power plant cooling needs would be satisfied would be changed. Industrial self-supplied water needs would be slightly increased to allow for increased business activity. Agriculture irrigation would be increased substantially, accompanied by some increase in drainage control to rejuvenate agricultural industries. Drainage control has an additional benefit to forest lands because commercially profitable tree species can be selectively favored by controlling the water table. Power plant cooling needs for freshwater withdrawal would be slightly less in the last planning period because only the energy needs of Area 2 would be met, rather than also help meet the needs of the regional power net. Water quality standards would be met by the simplest devices possible to enhance business expansion while lowering costs. This would result in certain Environmental Quality related needs that depend upon flood plain management being satisfied less, including: water recreation, visual and cultural, fish and wildlife, and water quality maintenance. The commercially exploitable aspects of these needs would be emphasized, however, including tourism and heavier use of facilities.

National Efficiency can be emphasized more than in the recommended program but there would be few changes. Costs for fulfilling power plant cooling needs would be reduced as less expensive devices would be stressed. This would include a fairly large increase in fresh water withdrawal in the last time phase but little change in fresh water consumption. There would be a considerable decrease in water recreation needs throughout all planning periods providing visitors with lower quality experiences. This reduction includes recreation man days, beaches, water surface and land facilities and greatly reduced costs. Erosion controls needs and costs would be reduced since they would not be needed to enhance the quality of the Area's environment. Similarly, cheaper and less secure visual and cultural devices would be used throughout the planning period as Environmental Quality is de-emphasized.

AREA 2

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020	
Publicly Supplied Water (mgd)	11	15	24	40	
Industrial Self-Supplied Water (mgd)	100	210	420	700	
Rural Water Supply (mgd)	2.7	3.5	3.9	2.9	
Irrigation Water: agriculture (1000 afy)	0.3	0.6	1.2	3.2	
non-agriculture (1000 afy)	0.1	0.7	1.4	2.0	
Power Plant Cooling: withdrawal, saline (cfs)					
brackish (cfs)					
fresh (cfs)	60	60	300	930	
consumption, brackish (cfs)					
fresh (cfs)	1	1	4	23	
Hydroelectric Power Generation (mw)	130	140	140	2000	
Navigation: commercial (m.tons annually)	1.8	2.5	4.6	8.5	
recreational boating (1000 boats)	12	13	24	35	
Water Recreation: visitor days (m.)	x	4.6	7.1	10.0	
stream or river (miles)	x	57	73	99	
water surface (1000 acres)	x	15	21	28	
beach (acres)	x	140	180	200	
pool (m. sq. ft.)	x	2.5	3.1	3.5	
land facilities (1000 acres)	x	7.9	10.2	12.4	
Fish & Wildlife: sport fishing man-days (m.)	1.1	1.1	1.3	1.5	
surface area, lake (acres)					
stream (acres)					
access, fresh (acres)	x	2	30	62	
salt (acres)					
anadromous (acres)	x	36	43	52	
piers (1000 feet)					
hunting man-days (m.)	0.66	0.67	0.78	0.91	
access (1000 sq. mi.)	x	0	0.35	0.55	
nature study man-days (m.)	0.20	0.21	0.24	0.28	
access (1000 acres)					
Water Quality Maint.: non-industrial (m. PEs)	0.14	0.16	0.19	0.22	
industrial (m. PEs)	3	7	15	30	
Flood Damage Reduction:					
avg. ann. damage, upstream (m.$)	0.11	0.17	0.30	0.59	
mainstream (m.$)	0.21	0.30	0.58	1.15	
tidal & hurricane (m.$)					
Drainage Control: cropland (1000 acres)	10	13	21	35	
forest land (1000 acres)	x	0	9	36	
wet land (1000 acres)					
Erosion Control: agriculture (1000 acres)	40	49	53	53	
urban (1000 acres)	100	120	130	140	
stream bank (mi.)	x	2	7	12	
coastal shoreline (mi.)					
Health: vector control and pollution control	x	x	x	x	
Visual & Cultural:					
landscape maintenance, unique natural (sq.mi.)	700	1450	1450	1450	
unique shoreline (mi.)					
high quality (sq.mi.)	400	2000	3600	5200	
diversity (sq.mi.)					
agriculture (sq.mi.)	x	x	x	x	
landscape development, quality (sq.mi.)					
diversity (sq.mi.)					
metro. amenities (mi.)					
" " (sq.mi.)					

AREA 2

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	15	23	35	15	24	40	15	25	43
	210	390	620	210	420	700	220	440	780
				3.5	3.9	2.9			
	3.7	12.5	18.2	0.6	1.2	3.2	3.7	12.5	14.5
	0.8	1.5	2.0	0.7	1.4	2.0	0.7	1.4	2.0
	60	0	0	60	300	2100	60	300	1200
	1	0	0	1	4	22	1	4	23
				140	140	2000			
	2.2	3.2	4.6	2.4	4.2	7.6	2.5	4.8	9.2
				13	24	35			
	4.6	7.1	10.0	4.0	6.2	9.3	4.7	7.2	10.0
	57	73	99	19	24	33	28	36	49
	15	21	28	4	6	8	8	11	15
	140	180	200	40	50	60	110	140	150
	2.5	3.1	3.5	0.8	1.0	1.2	1.9	2.4	2.6
	7.9	10.2	12.4	1.4	1.8	2.4	2.8	3.6	4.3
				1.1	1.3	1.5			
				2	30	62			
				36	63	52			
				0.67	0.78	0.91			
				0	0.35	0.55			
				0.21	0.24	0.28			
				0.16	0.19	0.22			
				7	15	30			
				0.17	0.30	0.59			
				0.30	0.58	1.15			
	15	25	41	13	21	35	15	25	41
	0	9	36	0	9	36	9	36	118
	49	53	53	47	50	50	49	53	53
	120	130	140	110	110	110	120	130	140
	2	7	12	0	1	2	1	3	5
	x	x	x	x	x	x	x	x	x
	1450	1450	1450	1450	1450	1450	Same	as	EQ
	2000	3600	5200	2000	3600	5200	Same	as	EQ

AREA 2

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	VC	x*	15.6*	x*
mainstream (1000 af)	VC,WQ	x*	x*	x*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	110	200	280
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		1.6*	2.5*	1.0*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow		x	x
chemical/biological				
potable water treat plants (mgd)	PS	1.1	2.1	3.6
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	6.3	0	0
secondary (90%) (m. PE removed)	WQ	0	14	27
advanced (95%) (m. PE removed)	WQ	0	0.75	1.47
effluent irrigation				
nutrient control				
stormwater discharge control				
acid mine drainage control				
septic tank control				
separate combined sewers				
Pumped Storage	HPG			x
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	1	x	x
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	1	0	4
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	18	x	161
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig.

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	2.6	6.6	4.3	Irrig	0.2	0.5	1.5	Irrig,Vc	2.6	6.6	1.5
PS,WQ	0	7.9	x	PS,WQ	0	8.9	x	PS,WQ	0	9.9	x
Pow**	110	180	220	Pow**	110	200	290	Pow**	110	220	330
Rur**	5.9	10.6	10.9	Rur**	5.1	8.9	12.9	Rur**	6.8	11.9	14.2
WQ	x	x	x					Pow			x
PS	1.1	2.0	2.8	PS	1.1	2.1	3.6	PS	1.1	2.3	4.2
				WQ	6.3	0	0				
				WQ	0	14	27				
				WQ	0	0.75	1.47				
WQ	x	x	x								
WQ	x	x	x								
WQ	x	x	x								
				HPG			x				
FDR,VC	2	82	27	FDR,VC	1	x	x	FDR,VC	1	x	x
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
				FDR	1	0	4	FDR	1	0	4
FDR,Drn,VC	414	827	827	FDR,Drn,C	18	x	161	FDR,Drn,VC	18	x	161
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x	x	Nav	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 2

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC,FW	1250	0	0
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)	VC,FW	500	500	500
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC,FW	0	0	0
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	600	600	600
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility				
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish				
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)	Pow			x
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs				
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	8	0	38

AREA 2

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC,FW	1250	500	500	VC,FW	50	0	0	Same as EQ			
VC,FW	500	500	500	VC,FW	0	0	0	" " "			
VC,FW	0	0	0	VC,FW	700	0	0	" " "			
VC,FW	600	600	600	VC,FW	1600	1600	1600	" " "			
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same as EQ			
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
Pow		x	x								
Pow		x	x								
				FW	x	x	x				
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	8	0	38	FDR	8	0	38

AREA 2

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE		
	1980	2000	2020
Water Development Costs:			
storage, upstream	0*	1.2*	0*
mainstream	0*	0*	0*
wells	0.8*	1.4*	0.6*
desalting			
Water Withdrawal and Conveyance Costs:			
inter-basin transfers			
public water supply	1.8	2.1	3.5
industrial self-supplied water	0.58	1.07	1.51
rural water supply	x	x	x
irrigation, agriculture	0	0.20	0.72
nonagriculture	0.39	0.45	0.42
Power Plant Cooling Water	0	0	25
Hydroelectric Power Generation			x
Navigation: commercial	0.3	0.5	36.0
recreation	0.5	0.6	0.8
Water Recreation	62	18	14
Fish and Wildlife: fishing	0.50	0.48	0.55
hunting	x	x	x
nature study	x	x	x
Water Quality Maint.: waste treatment, secondary	101	233	453
advanced	0	154	303
other ≠	31	0	0
Flood Damage Reduction: upstream	1.1	0	3.3
mainstream			
Drainage Control	0.10	0.42	0.92
Erosion Control	1.6	1.1	0.7
Health	x	x	x
Visual and Cultural	12.8	7.0	7.0
Summation of Available Estimated Costs	210	420	850

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.2	0.5	0.4	0	0.05	0.2	0.2	0.5	0.5
	0	3.4	0	0	3.8	0	0	4.2	0
	0.3	0.6	0.6	0.2	0.5	0.7	0.3	0.7	0.7
	1.8	2.0	2.8	1.8	2.1	3.5	1.8	2.7	4.0
	0.58	0.96	1.19	0.58	1.07	1.51	0.62	1.17	1.78
	x	x	x	x	x	x	x	x	x
	0.60	1.84	1.46	0	0.20	0.72	0.60	1.84	0.72
	0.42	0.45	0.39	0.39	0.45	0.42	0.39	0.45	0.42
	0	14	91	0	0	0	0	0	11
			x			x			x
	0	0	0	0.3	0.5	36.0	0.3	0.5	36.0
	←			0.5	0.6	0.8			→
	62	18	14	9	6	10	45	14	8
	←			0.50	0.48	0.55			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			101	233	453			→
	←			0	154	303			→
	←			31	0	0			→
	0	0	0	1.1	0	3.3	1.1	0	3.3
	0.17	0.48	0.98	0.10	0.42	0.92	0.32	0.78	1.90
	1.6	1.1	0.7	0.6	0.3	0.1	1.6	0.9	0.5
	x	x	x	x	x	x	x	x	x
	12.8	7.0	7.0	0.3	0	0	Same	as	EQ
	210	440	880	150	400	810	200	420	830

AREA 3 KENNEBEC RIVER BASIN

AREA 3

Kennebec River Basin. Area 3 consists of the portion of Maine drained by the Kennebec River and covers 5,870 square miles. Augusta, the State Capital of Maine, is by far the largest metropolitan center in the Area and is at its southern end. The Area's topography gradually changes from the wide flat valleys characteristic of a coastal plain to gentle foothills and mountains at the headwaters.

Rolling hills cover half of the Area and the other half is equally divided between steep hills and mountains. Nearly ten percent of all the mountain series in the NAR is found here. The majority of the landscape units are forest-town with lesser amounts of forest-wildland. Ninety percent of the Area is of high visual quality and the remainder is of medial quality.

Early settlements dotted the river valleys near the coast. The rivers were used for transportation and settlers prepared small clearings for a self-subsistence type of agriculture. Later, the high labor and small profit character of the farms turned settlers to more profitable occupations. Twentieth century development shows a decline in agriculture and an increase in manufacturing and forest industries.

The population of the Area in 1960 was 148,970 with a density of 25 people per square mile. The projected population for 2020 is 217,100.

Per capita income was 81 percent of the national average in 1959, and is projected to increase to 87 percent of the national average by 2020.

The 1960 employment of 54,600 is expected to increase to 90,300 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; paper and allied products; and lumber, wood products and furniture. Employment is expected to increase in all industries except for agriculture; mining; food and kindred products; textile mill products, and lumber, wood products and furniture.

Water is abundant in this Area. The Kennebec River is regulated by about 1.4 million acre-feet of usable storage in existing lakes and reservoirs. Most of this storage was developed for power and log driving. The latter is being phased out. There are significant water quality problems due to industrial and non-industrial discharges on the main stem below Madison, on the Sebasticonk River below Dexter and on the Carrabassett River below Kingfield.

Average annual runoff in Area 3 is approximately 6,500 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,060 m.g.d., and the corresponding seven-day minimum is about 80% of this total, or

1,650 m.g.d. (See Appendix C). The addition of 7 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 1,657 m.g.d., or 25% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 2,816 m.g.d., or 43% of the average runoff. Potential sources which would develop the increase of 1,159 m.g.d., include major storage, accounting for 33% of the increase; upstream storage, 41%, and ground water development, 26%.

Possible Alternative Planning Objectives. All three of the NAR planning objectives can be considered in Area 3. The high visual quality of the Area would most likely dictate that some Environmental Quality emphasis for preserving the natural resources of the Area would be included in any objective mix. Regional Development could be stressed to raise the per capita income which was 19% below the national average in 1960. National Efficiency could be emphasized to continue the presently increasing rate of economic growth.

Recommended Mixed Objective. It is recommended that Environmental Quality and National Efficiency receive equal emphasis in Area 3. This mixed objective can preserve the Area's natural resources along with the present rate of economic development. The greatest opportunities for maintanining the quality of the environment are in the upstream reaches where water recreation and landscape associated needs can be emphasized. Investments to conserve and improve forest land for industrial and recreational use can be made throughout the Area.

Needs to be Satisfied. Basic to the problems in the Area and the needs of most immediate and important consideration are water quality maintenance, publicly supplied and industrial self-supplied water, and visual and cultural. The emphasis of the mixed objective on the enhancement of environmental quality, tempered by the desire for growth in goods and services will rely heavily on adequate supplies of clean water, the maintenance of high quality landscapes, and the provision for steadily increasing numbers of recreators.

Publicly supplied water needs will increase throughout the period of this study to meet the needs of increased per capita use, although the rate of total use will not be highly significant since the projected population increase would lag behind the average for the NAR. Industrial self-supplied water needs will increase at a somewhat faster rate, particularly in the early time frames as the Area develops its economic productive capacity. Hydroelectric power generation needs are fairly large in this Area and grow rapidly over the last two time periods to meet industrial and regional needs. Fresh water withdrawal will be large in the last two time periods for power plant cooling. Water quality maintenance needs are key in Area 3

in order to satisfy the requirements of the other important needs. Growth in quality recreational experiences and industrial activities requires the support of high water quality standards. Recreation boating needs grow very rapidly in this Area. The Area will support many activities associated with high environmental quality since two thirds of the basin can be classified as having high visual quality.

Other Area needs which can be considered of moderate importance in achieving the mixed objective are power plant cooling water for consumption, agricultural irrigation, recreational boating, fish and wildlife, and erosion control. Relatively minor needs are those of drainage control, health, rural water supply, flood damage reduction, and commercial navigation. Needs for agriculture irrigation and cropland drainage control, however, have very rapid growth rates through the planning period. Provision for power plant cooling water needs would help the Area's industrial development and the efficiency of the Region's power system. Stream bank erosion control needs increase in the early phases of the planning period and are consistent with the visual and cultural needs for the maintenance of landscape quality and diversity.

Devices. Water quality control facilities will be needed in all time phases with secondary and advanced treatment used in the middle and late time periods. These facilities will, in conjunction with water storage and water withdrawal facilities, provide for the needs of irrigation, publicly supplied water, power plant cooling, industrial self-supplied water, and water quality maintenance. These devices will provide the quality and quantity of water that will be essential to the development of normal growth rates in goods and services and provide the foundation for maintaining environmental quality.

Water quality maintenance facilities for all time periods will include waste treatment plants, nutrient and stormwater control, and the separation of combined sewers. Storage facilities will feature upstream reservoirs in all time periods and water withdrawal facilities will depend mainly on fresh water intakes and wells. Publicly supplied and industrial self-supplied water needs will use pipelines and pumping stations to provide for an economical distribution of available supplies.

Water and land management devices will be necessary throughout the entire planning period. The entire thrust of preserving and enhancing the Area's environmental quality through land control will depend not only upon key water quality devices, but also upon the important land management and acquisition devices. Land acquisition devices would insure that the development of particular wilderness areas can be halted and that it can be done as economically as possible. At the same time the Water/Land devices, such as flood plain and watershed management, erosion protection and drainage practices would pro-

vide for the needs of erosion and drainage control, flood damage reduction and visual and cultural. If the majority of these devices are not provided in the early time period, it will be difficult to achieve the recommended program.

A high degree of effectiveness for flood plain management is primarily due to the topography of the basin and the low degree of urban development. The early and mid time frame application of this device would eliminate the need for reservoir storage for floods thus decreasing the encroachment upon the Area's natural environment.

With the meeting of water quality standards, the use of biological devices will become more effective and provide quality outdoor experiences. These devices would mainly consist of fish and wildlife habitat management, fish and game stocking and insect control.

Benefits. Fulfilling water quality management needs should provide the largest net benefits for Area 3's program. These benefits would come from improvements in environmental quality that would help fulfill needs such as visual and cultural, water recreation and fish and wildlife. There would also be benefits from the reduction in costs of meeting publicly supplied water and industrial self-supplied water needs that require water of a minimum quality.

Fulfillment of industrial self-supplied and publicly supplied water needs will also provide fairly large benefits to the Area as they aid the regular development of the economy and as they meet the population's water requirements.

Visual and cultural benefits can be high in Area 3 if appropriate controls are implemented to prevent erratic development. Water recreation, fish and wildlife, and erosion control benefits will not be large because of the abundance of resources in the Area. Continued environmental protection, however, is necessary for high quality tourist experiences, so facilities must be well maintained for the expected level of use.

Benefits from power plant cooling and hydroelectric power generation will be large in this Area because of their helping meet the fairly critical, National Income related needs. Electricity that is within the Area will reduce costs of the importation of electricity that will be required to meet local industrial and population needs.

Benefits from drainage control, health and rural water supply will be fairly small. Flood damage reduction and commercial navigation benefits wil be negligible.

Costs. Costs for hydroelectric power generation are high for target years 2000 and 2020 because the use of pumped storage facilities requires careful selection of sites compatible with the environment. Costs of water quality maintenance will be high because of the large amount of treatment required especially the secondary waste treatment in 2000 and 2020. Recreation and visual and cultural costs are fairly high in the early planning period in order that these needs be met before the costs become excessive Power cooling costs become high in 2020 mainly because of the non-condensing facilities needed to reduce freshwater use in keeping with the environmental quality emphasis.

The competition between industrial self-supplied water needs and water needs for fish and wildlife will cause some cost increases for both of them.

Alternative Programs. If Regional Development were chosen to be emphasized throughout Area 3, the needs of industrial water supply, power plant cooling and forest drainage control would increase, while those for water recreation would slightly decrease. The needs for water quality maintenance and upstream flood damage reduction would remain about the same but would be satisfied in a different manner. Industrial water supply would be somewhat greater in each time period, increasing by about 10% in 2020. Power plant cooling needs for fresh water withdrawal would be substantially greater to aid in local economic development. Forest drainage control would be increased substantially to aid the local lumber and wood products industry. Recreational development would be concentrated on smaller land areas which would result in higher density use as transportation to the sites would be improved. Upstream flood damages would be controlled by limited watershed and flood plain management in the first two planning periods, supplemented by structures in the last planning period.

If National Income needs were to be emphasized alone throughout Area 3, there would be large reductions in the needs for agricultural irrigation water and water recreation in all periods. A small decrease would occur in the need for cropland drainage control in all periods while forest drainage control needs would have a large increase. The decreases in needs would occur because of the increases in efficiency in the Area's industries. Allowances for fresh water withdrawals and consumption would be increased and presently used non-condensing facilities would be phased out for the most economical production of electricity. Recreational boating harbors would not be built as their facilities would be combined with commercial harbors to reduce costs. Fewer beach and pool areas and less land for facilities would be made available in the Area to reduce recreation costs and resulting in a decrease of the quality of experiences. Water quality maintenance would be achieved without the use of nutrient control, stormwater discharge and separation of combined sewers to reduce costs to local industries and popula-

tions. Advanced waste treatment would be necessary in the last two time periods. More storage would be built in the last planning period and less flood plain management would be used for flood damage reduction to reduce interference with industrial use of flood plains. Visual and cultural needs would be achieved by cheaper land management devices rather than the more expensive use of purchase and easements.

Environmental Quality needs could not easily be emphasized further in Area 3. The presently recommended program already stresses Environmental Quality associated needs to their limits. It is felt that the present EQ emphasis in the recommended program is compatible with the National Efficiency portion of the mixed objective. A large decrease in power plant cooling needs could be achieved, however, which would decrease fresh water withdrawal and consumption to zero and, therefore, greatly decrease the costs to Environmental Quality associated needs. This change would significantly increase energy costs, however, as non-condensing power generation facilities would be used.

AREA 3

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	17	21	29	41
Industrial Self-Supplied Water (mgd)	50	80	130	190
Rural Water Supply (mgd)	3.0	3.7	4.7	4.7
Irrigation Water: agriculture (1000 afy)	0.1	5.8	20.1	25.7
non-agriculture (1000 afy)	0	1.3	2.1	3.0
Power Plant Cooling: withdrawal, saline (cfs)				
brackish (cfs)				
fresh (cfs)	0	0	280	1280
consumption, brackish (cfs)				
fresh (cfs)	0	0	3	18
Hydroelectric Power Generation (mw)	210	220	1720	2800
Navigation: commercial (m.tons annually)	0.03	0.04	0.08	0.10
recreational boating (1000 boats)	13	17	40	65
Water Recreation: visitor days (m.)	x	5.5	8.4	11.8
stream or river (miles)	x	71	89	120
water surface (1000 acres)	x	18	26	34
beach (acres)	x	170	200	230
pool (m. sq. ft.)	x	2.9	3.6	4.0
land facilities (1000 acres)	x	9.5	12.1	14.6
Fish & Wildlife: sport fishing man-days (m.)	0.7	1.2	1.4	1.6
surface area, lake (acres)				
stream (acres)				
access, fresh (acres)	x	32	56	84
salt (acres)				
anadromous (acres)	x	23	27	32
piers (1000 feet)				
hunting man-days (m.)	0.39	0.48	0.56	0.66
access (1000 sq. mi.)	x	0.2	0.4	0.6
nature study man-days (m.)	0.17	0.22	0.26	0.30
access (1000 acres)				
Water Quality Maint.: non-industrial (m. PEs)	0.15	0.17	0.19	0.22
industrial (m. PEs)	1.6	2.7	4.5	7.7
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	0.29	0.42	0.67	1.22
mainstream (m.$)	0.5	0.7	1.4	2.8
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	19	29	48	81
forest land (1000 acres)	x	0	0	0
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	78	100	112	113
urban (1000 acres)	98	105	111	116
stream bank (mi.)	x	3	9	15
coastal shoreline (mi.)				
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)				
unique shoreline (mi.)				
high quality (sq.mi.)	x	1600	3200	4800
diversity (sq.mi.)	x	x	x	x
agriculture (sq.mi.)	x	x	x	x
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	20	27	35	21	29	41	21	30	41
	80	120	170	80	130	190	80	140	210
				3.7	4.7	4.7			
	5.8	20.1	25.7	0.2	0.8	2.2	5.8	20.1	21.5
	1.3	2.1	3.0	1.1	2.0	3.0	1.2	2.0	3.0
	0	0	0	0	280	2900	0	1000	2000
	0	0	0	0	3	29	0	9	39
				220	1720	2800			
	0.04	0.08	0.10	0.05	0.11	0.17	0.06	0.12	0.20
				17	40	65			
	5.5	8.4	11.8	4.8	7.3	10.9	5.6	8.6	11.8
	71	89	120	24	29	40	35	44	59
	18	26	34	5	7	9	9	14	18
	170	200	230	50	60	70	130	160	180
	2.9	3.6	4.0	0.9	1.1	1.4	2.3	2.8	3.0
	9.5	12.1	14.6	1.7	2.2	2.9	3.3	4.2	5.0
				1.2	1.4	1.6			
				32	56	84			
				23	27	32			
				0.48	0.56	0.66			
				0.2	0.4	0.6			
				0.22	0.26	0.30			
				0.17	0.19	0.22			
				2.7	4.5	7.7			
				0.42	0.67	1.22			
				0.7	1.4	2.8			
	29	48	81	25	40	69	29	48	81
	0	16	64	0	16	64	16	64	209
	100	112	113	91	98	99	100	112	113
	105	111	116	98	98	98	105	111	116
	3	9	15	1	2	3	1	4	7
	x	x	x	x	x	x	x	x	x
	1600	3200	4800	1600	3200	4800	Same	as	EQ

AREA 3

DEVICES--incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)		3.7*	17.1*	0*
mainstream (1000 af)	WQ		x*	x*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	32	52	66
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		6.4*	14.5*	5.5*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow			x
chemical/biological				
potable water treat plants (mgd)	PS	2.3	4.7	7.6
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	2.5	0	0
secondary (90%) (m. PE removed)	WQ	0	4.2	7.1
advanced (95%) (m. PE removed)	WQ	0	0.24	0.39
effluent irrigation				
nutrient control	WQ	x	x	x
stormwater discharge control	WQ	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ	x	x	x
Pumped Storage	HPG		x	x
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	6	30	8
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)				
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	130	260	260
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig.

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	4.3	10.7	4.2	Irrig	0.08	0.45	1.05	Irrig	4.3	10.7	1.1
WQ		x	x	WQ		x	x	WQ		x	x
Pow**	32	45	50	Pow**	32	52	66	Pow**	34	58	81
Rur**	4.6	8.1	5.5	Rur**	3.4	5.3	6.3	Rur**	4.7	8.5	6.2
								Pow			x
PS	1.7	4.1	5.0	PS	2.3	4.7	7.6	PS	2.3	5.3	7.0
				WQ	2.5	0	0				
				WQ	0	4.2	7.1				
				WQ	0	0.24	0.39				
WQ	x	x	x								
WQ	x	x	x								
WQ	x	x	x								
				HPG		x	x				
FDR,VC	6	30	8	FDR,VC	4	3	x	FDR,VC	4	3	x
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
				FDR	0	0	8	FDR	0	0	8
FDR,Drn,VC	130	260	260	FDR,Drn,VC	x	x	170	FDR,Drn,VC	x	x	170
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 3

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	300	300	300
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)	VC, FW	500	500	500
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW	800	800	800
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC, Rec	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs				
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	0	0	0

	ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
	Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
	VC, FW	500	500	500					Same	as	EQ	
	VC, FW	500	500	500					"	"	"	
	VC, FW	600	600	600	VC, FW	1600	1600	1600	"	"	"	
	Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
	Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
					FW	x	x	x				
	VC, Rec	x	x	x	VC, Rec	x	x	x	Same	as	EQ	
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					Hlth	x	x	x				
	WQ		x		WQ		x		WQ		x	
	Pow		x	x								
					FW	x	x	x				
	Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
	FDR	0	0	0	FDR	0	0	130	FDR	0	0	130

AREA 3

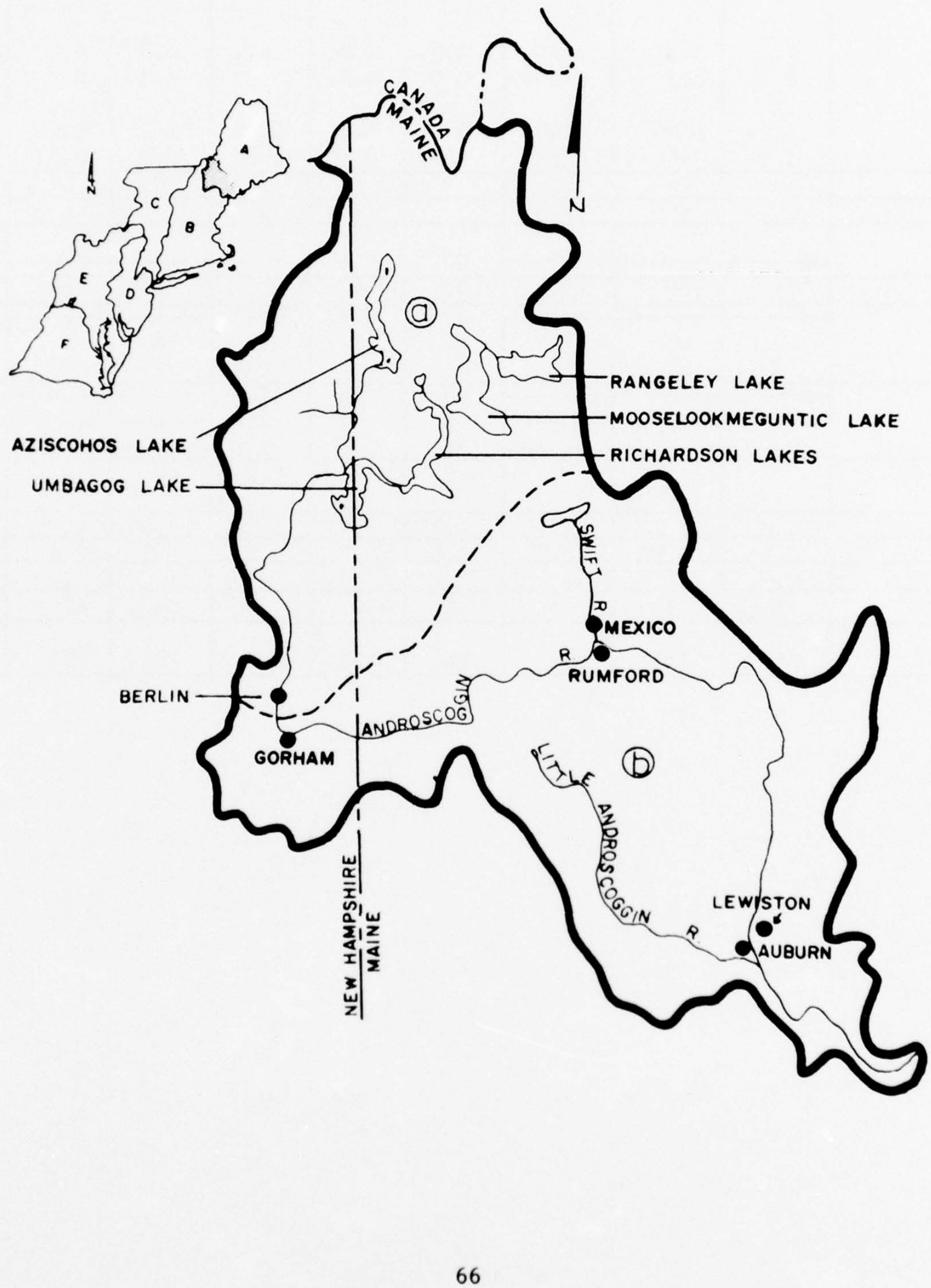
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	0.4*	1.4*	0*	
mainstream				
wells	3.5*	7.9*	2.9*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	3.0	6.0	9.5	
industrial self-supplied water	0.2	0.2	0.3	
rural water supply	x	x	x	
irrigation, agriculture	1.15	2.90	1.40	
nonagriculture	1.04	0.62	0.62	
Power Plant Cooling Water	0	0	22	
Hydroelectric Power Generation		x	x	
Navigation: commercial				
recreation	0.2	0.6	1.1	
Water Recreation	74	20	15	
Fish and Wildlife: fishing	0.45	0.37	0.45	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	65	104	174	
advanced	0	48	30	
other ≠	36	0	0	
Flood Damage Reduction: upstream	0	0	0	
mainstream				
Drainage Control	0.33	0.63	1.10	
Erosion Control	2.6	1.7	0.7	
Health	x	x	x	
Visual and Cultural	14	14	14	
Summation of Available Estimated Costs	200	210	320	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.3	0.8	0.4	0.02	0.05	0.13	0.3	0.8	0.1
	0.4	0.5	0.4	0.3	0.3	0.4	0.4	0.5	0.4
	1.2	5.3	6.5	3.0	6.0	9.5	3.0	6.6	8.4
	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.4
	x	x	x	x	x	x	x	x	x
	1.15	2.90	1.40	0.06	0.20	0.49	1.15	2.90	0.49
	1.04	0.62	0.62	0.99	0.65	0.65	1.02	0.62	0.65
	0	14	91	0	0	0	0	2	11
		x	x		x	x		x	x
	←			0.2	0.6	1.1			→
	74	20	15	10	6	9	53	16	8
	←			0.45	0.37	0.45			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			65	104	174			→
	←			0	48	80			→
	←			36	0	0			→
				0	0	8.2	0	0	8.2
	0.33	0.90	1.90	0.20	0.77	1.76	0.60	1.43	3.68
	2.6	1.7	0.7	0.9	0.5	0.2	2.5	1.5	0.5
	x	x	x	x	x	x	x	x	x
	18	18	18	0	0	0	Same	as	EQ
	200	220	390	120	170	290	180	200	320

AREA 4 ANDROSCOGGIN RIVER BASIN



AREA 4

Androscoggin River Basin. Area 4 includes the portions of Maine and New Hampshire drained by the Androscoggin River. Sub-area a is the northern portion of the basin above Gorham, Maine, and sub-area b comprises the rest. The topography of this Area of 3,450 square miles varies from rugged base mountains to gently rolling coastal lowland. Part of the White Mountain National Forest is located in the Area. Lewiston and Auburn, Maine are close together near the mouth of Androscoggin River and are the Area's only large metropolitan cities.

The mountain landscape series takes up nearly half of the Area with the remainder equally divided between steep hills and rolling hills. Three fourths of the Area's land use is forest-wildland with the remaining classified as forest-town. The entire Area's landscape is of high visual quality.

Early settlers established crude shelters in the coastal valleys and along the major streams and developed agriculture of a subsistence nature. Later the colonists diverted their energies to fishing, lumbering, shipbuilding and fur trading. The twentieth century has shown a decline in agriculture and increases in manufacturing and industrial activities.

The 1960 population of Area 4 was 130,623, with a population density of 38 per square mile. The sub-areas' population figures were widely divergent with sub-area a totalling 27,800, or 20 people per square mile, and sub-area b having a population of 102,823, or a density of 49 per square mile. The projected population for 2020 is 201,200.

Per capita income was 85 percent of the national average in 1959 and is projected to increase to 91 percent by 2020.

The 1960 employment of 50,800 is expected to increase to 84,000 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; textile mill products; and lumber, wood products and furniture. Employment is expected to decrease in agriculture, forestry and fisheries; food and kindred products; textile mill products; and lumber, wood products and furniture.

The Androscoggin River basin is presently regulated by about 750,000 acre feet of usable storage, which is primarily used for power. Although water is relatively plentiful, serious pollution problems exist below Berlin, New Hampshire and Rumford, Maine as a result of large quantities of waste discharge. The Little Androscoggin River is also badly degraded in its lower reaches.

Average annual runoff in Area 4 is approximately 3,985 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,400 m.g.d. and the corresponding seven-day minimum is about 80% of this or 1,115 m.g.d. (See Appendix C). The addition of 9 m.g.d. as an allowance for

consumptive losses results in an existing firm resource available for use of about 1,124 m.g.d., or 28% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 2,442 m.g.d., or 61% of the average runoff. Potential sources which would develop the increase of 1,318 m.g.d., include major storage, accounting for 56% of the increase; upstream storage, 30%, and ground water development, 14%.

Possible Alternative Planning Objectives. The two sub-areas of Area 4 vary so widely in topography, population and economic activity that a different mix of objectives can be considered for each.

Both Environmental Quality and National Efficiency can be emphasized in each sub-area, but the lack of accessibility into the Area will limit the amount of emphasis that can be placed on Regional Development.

Recommended Mixed Objective. It is recommended for sub-area a that Environmental Quality, augmented by National Efficiency, be the planning objective. This portion of the Area is unique in that its environment is virtually unblemished by any type of development and ought to be preserved in its natural state. Present forest management practices should be continued and a program to improve the environment for recreational purposes ought to be implemented.

It is recommended for sub-area b that equal emphasis be placed on Environmental Quality and National Efficiency. The present trends of industrial and urban development should be continued to maintain the Area's economic viability, and a program should be implemented to improve the sub-area's already severely polluted water to maintain the quality of the environment.

Needs to be Satisfied. Sub-area a will serve a major source of recreational and other activities associated with the Area's high environmental quality. The quantity and quality of the sub-area's resources to provide these activities points to the importance of early satisfaction of related needs including water quality maintenance, water recreation, fish and wildlife, and visual and cultural. These needs will have steady growth rates during the planning period. The provision of adequate supplies of clean water and maintaining high quality landscape will be key to attaining the sub-area's other important needs. Attaining access for fresh and anadromous sport fishing will be important to attaining the fish and wildlife needs.

Sub-area b will be more dependent on the important needs of publicly supplied water, industrial self-supplied water, and flood damage reduction throughout the planning period and power plant cooling water withdrawal and consumption in the late time phase.

Satisfying these needs would provide the foundation for continued economic stability and growth that is important to this sub-area's recommended mixed objective.

This is not to imply that each need is restricted to a particular portion of the Area but rather to emphasize the different characteristics of each sub-area. Growth of the industrial sector in the lower sub-area b will be heavily subject to maintenance of high water quality standards and to meeting the needs for water recreation, fish and wildlife, and visual and cultural and the very high per capita mainstrean flood damage reduction needs. The solution, therefore, for fulfilling the Area's relatively small needs and for achieving its mixed objective is the cleaning up of the present pollution problems and the safeguarding of those portions of the Area not yet degraded.

Some needs in the Area will have very large growth rates throughout the planning period and include agricultural irrigation and cropland drainage. Needs of lesser importance in the Area are flood damage reduction, drainage control, hydroelectric power generation, and health needs.

Devices. Water quality control and land control devices will be very important throughout Area 4. The use of water quality control devices will ensure the adequate growth of recreational development and the reasonable use of the Area's water for industrial and public use. These control devices consist of cooling towers for power plant cooling water and waste and water treatment plants through the Area along with nutrient control and separation of combined sewers in sub-area b. Land acquisition for visual and cultural needs by means of zoning and/or tax incentive subsidies and other appropriate regulations should be accomplished throughout the planning period. This would establish the early development and maintenance of high quality and unique natural landscapes and sustain these efforts in each time period. Land access devices, specifically parking areas and trails, are important corollary actions to make full use of an improved environment.

Additional water management devices will be required for irrigation water, publicly supplied and industrial self-supplied water, flood damage reduction and water recreation needs. These devices include reservoirs and withdrawal facilities such as fresh water intakes and wells, as well as non-structural measures for flood damage reduction. Wells will also provide for the small rural water supply needs.

Flood plain management for flood damage reduction will be highly effective in Area 4. This is due to the steepness of the topography and the positive local attitudes towards this device. If such management is accomplished early in the planning period, it will eliminate

the need for upstream storage for flood damage reduction. Adequately planned, this device will also satisfy a portion of the Visual and Cultural needs of sub-area b. Erosion and drainage control needs can be fulfilled by watershed management, drainage practices and land treatment for erosion protection. Biological devices will provide for many fish and wildlife needs and will consist mainly of habitat management and wildlife stocking. Land controls will also be necessary for fish and wildlife needs, especially for access to hunting and fishing. These biological devices will also be effective only if the key devices of water quality maintenance and land acquisition are successfully implemented. Water quality control is also key to the success of land control for fish and wildlife needs.

Benefits. Water quality maintenance will provide large benefits in sub-area a by raising the quality of the environment and by providing water that is more useful for economic purposes.

Satisfying water recreation needs will bring high benefits to the Area, especially to the upstream and rural portions where recreation is an integral part of the local economy.

Meeting visual and cultural and fish and wildlife needs will be beneficial to the whole Area but especially to sub-area a where they will provide further incentive for recreational participation.

Sub-area b will receive fairly large benefits from fulfillment of industrial self-supplied water, publicly supplied water, flood damage reduction, power plant cooling and hydroelectric power generation needs. Sub-area b will also receive moderately large benefits from Environmental Quality related needs. This sub-area's needs are oriented more towards recovery rather than preservation of its natural resources.

Erosion control will provide significant benefits, especially on the lower Androscoggin River where soils developed on marine sediments erode easily when supporting cultivated crops. Flood damage reduction needs of the Area are among the most serious in Maine. The proposed flood control devices will bring fairly high benefits to the numerous damage centers in the Area as well as significant benefits to visual and cultural, water recreation and fish and wildlife needs through multiple use of flood plains.

Costs. Water quality maintenance costs will be high, especially in sub-area b, due to the degree of treatment required. All treatment costs in 2000 and 2020 are incurred using secondary and advanced treatment methods. Water recreation costs will be high in 1980 in order to provide facilities necessary to meet the large increment in participation at that time.

Power plant cooling costs are fairly high in 2020 because of the need for an increase in power production without excessive freshwater withdrawal. Hydroelectric power costs, such as environmental impacts,

will be fairly high in 2020. This is due to the use of the available pumped storage sites in this Area to meet system energy needs of this and surrounding Areas.

Flood damage reduction costs will be small but are important because of the size of the damages and because of the problem of obtaining industrial siting in sub-area b at the lowest possible cost. Irrigation water costs will also be low, but fairly important as they aid the income of sub-area b.

Alternative Programs. If Regional Department were chosen to be emphasized throughout the Area the program would be designed to increase economic opportunities and industrial expansion. As a consequence the needs would be increased for industrial self-supplied water, irrigation water, power plant cooling, and forest land drainage control. The devices would change for satisfying the needs of upstream flood damage reduction and visual and cultural. Industrial water allowances would be increased and power generation in the Area would be increased but with relaxed constraints on fresh water withdrawals and consumption for power plant cooling. Agriculture irrigation water needs would greatly expand to take advantage of increased production potential and to encourage expanded farming. Forest drainage control needs would also increase to help the lumbering industry. The density of water recreation activities would be increased so that private enterprise might be encouraged to help satisfy the need for facilities and development. This density change would be achieved by increased investment in land transportation providing access to recreation facilities and by reduced investment in beach areas and facilities. Upstream flood damage reduction would be achieved by a greater emphasis on structures and less on flood plain management. Landscape maintainence would be pursued with greater use of purchases and easements and less use of zoning and/or tax incentives to increase development flexibility and certainty.

If Environmental Quality were chosen the greatest changes in the needs would be increases in agriculture irrigation and reductions in power plant cooling. Costs would increase to fulfill power generation needs because cooling water withdrawals would be virtually eliminated. Agriculture irrigation needs would be greatly expanded to ensure landscape quality. Flood damage reduction would be achieved through almost exclusive reliance on watershed and flood plain management techniques to avoid structures which would interfere with Environmental Quality related needs.

If National Efficiency were chosen the only major increase in the needs to be fulfilled would be water withdrawals for power cooling. This water use change would reduce power generation costs by eliminating the use of non-condensing facilities and still fulfill the power needs of the Area and of the region's grid. Agricultural irrigation water needs would substantially decrease as the industry's efficiency becomes of prime interest rather than how well it could aid the Area's total level of income. Cropland drainage needs would decrease for the same reason. Flood damage reduction needs would be partially met through increased use of reservoir storage and less use of flood plain management at decreased costs. Nutrient control, storm water discharge control and separation of combined sewers would not be used for water quality maintenance in sub-area a to reduce costs.

AREA 4

NEEDS-cumulative		Pres.	MIXED OBJECTIVE 1980	MIXED OBJECTIVE 2000	MIXED OBJECTIVE 2020
Publicly Supplied Water	(mgd)	14	18	23	32
Industrial Self-Supplied Water	(mgd)	90	140	210	310
Rural Water Supply	(mgd)	1.5	1.9	2.1	2.1
Irrigation Water: agriculture	(1000 afy)	0.3	3.6	9.7	12.2
non-agriculture	(1000 afy)	0.4	1.6	2.8	4.0
Power Plant Cooling: withdrawal, saline	(cfs)				
brackish	(cfs)				
fresh	(cfs)	0	0	0	410
consumption, brackish	(cfs)				
fresh	(cfs)	0	0	0	20
Hydroelectric Power Generation	(mw)	160	160	160	1100
Navigation: commercial	(m. tons annually)				
recreational boating	(1000 boats)	11	12	19	27
Water Recreation: visitor days	(m.)	x	3.8	5.7	8.0
stream or river	(miles)	x	45	55	75
water surface	(1000 acres)	x	12	17	23
beach	(acres)	x	120	140	160
pool	(m. sq. ft.)	x	2.0	2.5	2.7
land facilities	(1000 acres)	x	6.6	8.2	9.9
Fish & Wildlife: sport fishing man-days	(m.)	0.8	1.2	1.4	1.7
surface area, lake	(acres)				
stream	(acres)				
access, fresh	(acres)	x	22	46	76
salt	(acres)				
anadromous	(acres)	x	0	0	0
piers	(1000 feet)				
hunting man-days	(m.)	0.37	0.41	0.48	0.56
access	(1000 sq. mi.)	x	0.05	0.15	0.30
nature study man-days	(m.)	0.20	0.24	0.28	0.32
access	(1000 acres)				
Water Quality Maint.: non-industrial	(m. PEs)	0.13	0.14	0.16	0.18
industrial	(m. PEs)	2.5	4.3	7.0	11.9
Flood Damage Reduction:					
avg. ann. damage, upstream	(m.$)	0.2	0.3	0.6	1.3
mainstream	(m.$)	1.1	1.6	3.0	6.3
tidal & hurricane	(m.$)				
Drainage Control: cropland	(1000 acres)	6	9	15	24
forest land	(1000 acres)	x	0	5	20
wet land	(1000 acres)				
Erosion Control: agriculture	(1000 acres)	28	42	49	50
urban	(1000 acres)	96	99	107	113
stream bank	(mi.)	x	2	6	10
coastal shoreline	(mi.)				
Health: vector control and pollution control		x	x	x	x
Visual & Cultural:					
landscape maintenance, unique natural	(sq.mi.)	200	200	200	200
unique shoreline	(mi.)				
high quality	(sq.mi.)	x	1500	2500	3300
diversity	(sq.mi.)				
agriculture	(sq.mi.)				
landscape development, quality	(sq.mi.)				
diversity	(sq.mi.)				
metro. amenities	(mi.)				
" "	(sq.mi.)				

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
17	20	26	18	23	32	18	23	33
140	200	270	140	210	310	140	230	340
			1.9	2.1	2.1			
5.7	17.1	21.5	1.5	2.3	2.9	5.7	17.1	17.7
1.6	2.8	4.0	1.5	2.7	4.0	1.5	2.7	4.0
0	0	30	0	0	800	0	820	900
0	0	10	0	0	14	0	14	31
			160	160	1100			
			12	19	27			
3.8	5.7	8.0	3.3	5.0	7.5	3.9	5.8	8.0
45	55	75	15	18	25	22	27	37
12	17	23	3	4	6	6	9	12
120	140	160	30	40	50	90	110	120
2.0	2.5	2.7	0.6	0.8	1.0	1.6	1.9	2.1
6.6	8.2	9.9	1.2	1.5	1.9	2.3	2.9	3.4
			1.2	1.4	1.7			
			22	46	76			
			23	27	32			
			0.41	0.48	0.56			
			0.05	0.15	0.30			
			0.24	0.28	0.32			
			0.14	0.16	0.18			
			4.3	7.0	11.9			
			0.3	0.6	1.3			
1.6	3.0	6.3	1.6	3.0	6.3	Same	as	NE
9	15	24	8	13	20	9	15	24
0	5	20	0	5	20	5	20	65
42	49	50	37	42	43	42	49	50
99	107	113	96	97	97	99	107	113
2	6	10	0	1	2	1	3	5
x	x	x	x	x	x	x	x	x
200	200	200	200	200	200	Same	as	EQ
1100	2200	3300	1100	2200	3300	Same	as	EQ

AREA 4

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	Rec	7.0*	5.7*	x*
mainstream (1000 af)	Rec, WQ	x*	x*	x*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Irrig	47	75	91
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		3.1*	7.5*	3.0*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow			x
chemical/biological				
potable water treat plants (mgd)	PS	2.5	1.9	3.7
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	3.8	0	0
secondary (90%) (m. PE removed)	WQ	0	6.4	10.8
advanced (95%) (m. PE removed)	WQ	0	0.36	0.60
effluent irrigation				
nutrient control	WQ	x	x	x
stormwater discharge control				
acid mine drainage control				
septic tank control				
separate combined sewers	WQ	x	x	x
Pumped Storage	HPG			x
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	1.5	9	3
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	0.5	0.5	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	150	330	260
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig.

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig,Rec	4.1	8.6	3.3	Irrig	0.9	0.6	0.5	Irrig,Rec	4.1	8.6	1.0
PS,Rec,WQ	2.0	x	x	PS,WQ	3.3	x	x	PS,Rec,WQ	3.3	x	x
**	47	65	67	Pow**	47	75	91	Pow**	50	86	111
Rur**	5.6	8.0	6.0	Rur**	5.3	7.5	8.0	Rur**	6.2	9.8	9.3
Pow			x	Pow			x	Pow		x	x
PS	1.8	1.1	1.3	PS	2.5	1.9	3.7	PS	2.5	1.9	4.2
				WQ	3.8	0	0				
				WQ	0	6.4	10.8				
				WQ	0	0.36	0.60				
WQ	x	x	x					WQ	x	x	x
				HPG			x				
FDR,VC	3	18	5	FDR,VC	x	x	1	FDR,VC	x	x	1
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
				FDR	1.0	1.0	0	FDR	1.0	1.0	0
FDR,Drn,VC	260	530	530	FDR,Drn,VC	30	130	x	FDR,Drn,VC	30	130	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 4

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC,FW	0	0	0
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)	VC,FW	0	0	0
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	1500	1000	800
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility				
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish				
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow			x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs				
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	6	13	0
Mainstream Flood Control Storage (1000af)	FDR	0	58	0

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	400	400	400	VC,FW	0	0	0	Same as	EQ		
VC, FW	400	400	400	VC,FW	0	0	0	" "	"		
VC, FW	300	300	300	VC, FW	1100	1100	1100	" "	"		
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
								Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW		x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
Pow			x								
				FW	x	x	x				
~~Rec~~	~~x~~	~~x~~	~~x~~	~~Rec~~	~~x~~	~~x~~	~~x~~	~~Rec~~	~~x~~	~~x~~	~~x~~
FDR	0	0	0	FDR	12	26	0	FDR	12	26	0
FDR	0	0	0	FDR	0	58	0	FDR	0	58	0

AREA 4

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	0.6*	0.4*	0*	
mainstream	0*	0*	0*	
wells	1.7*	4.1*	1.6*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	3.0	2.0	3.0	
industrial self-supplied water	0.25	0.40	0.48	
rural water supply	x	x	x	
irrigation, agriculture	0.66	1.29	0.59	
nonagriculture	1.00	0.85	1.00	
Power Plant Cooling Water	0	0	12	
Hydroelectric Power Generation			x	
Navigation: commercial				
recreation	0.1	0.3	0.6	
Water Recreation	48.0	12.7	8.9	
Fish and Wildlife: fishing	0.60	0.37	0.46	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	68	109	185	
advanced	0	74	123	
other ƒ	31	0	0	
Flood Damage Reduction: upstream	1.6	1.6	0	
mainstream	0	12.5	0	
Drainage Control	0.10	0.28	0.55	
Erosion Control	1.5	1.5	0.7	
Health	x	x	x	
Visual and Cultural	0	0	0	
Summation of Available Estimated Costs	160	220	340	

*From the supply model and includes OMR costs.

ƒ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.3	0.6	0.3	0.07	0.07	0.05	0.3	0.6	0.05
	1.2	0	0	2.0	0	0	2.0	0	0
	0.4	0.6	0.4	0.4	0.5	0.5	0.5	0.6	0.6
	2.0	1.3	1.4	3.0	2.0	3.0	3.0	2.0	3.6
	0.25	0.35	0.36	0.25	0.40	0.48	0.26	0.46	0.59
	x	x	x	x	x	x	x	x	x
	1.06	2.32	0.98	0.26	0.26	0.20	1.06	2.32	0.20
	1.02	0.85	0.99	0.99	0.85	1.02	0.99	0.85	1.02
	0	0	34	0	0	0	0	9	17
			x			x			x
				0.1	0.3	0.6			
	48.0	12.7	8.9	3.5	3.8	5.9	33.6	9.6	4.4
				0.60	0.37	0.46			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				68	109	185			
				0	74	123			
				31	0	0			
	0	0	0	3.3	2.1	0	3.3	2.1	0
				0	12.5	0	0	12.5	0
	0.10	0.28	0.55	0.07	0.25	0.48	0.18	0.45	1.05
	1.5	1.5	0.7	0.6	0.6	0.2	1.5	1.3	0.5
	x	x	x	x	x	x	x	x	x
	14	14	14	0	0	0	Same as		EQ
	170	220	370	110	210	320	160	240	350

AREA 5 MAINE COASTAL BASINS

AREA 5

Maine Coastal Basins. Area 5 covers 6,231 square miles entirely in the State of Maine and is divided into two sub-areas. The St. Croix River, as it flows into Canada comprises sub-area a. The Maine coastal basins from the Canadian border to Cape Small comprise sub-area b. The topography varies from marshland and rolling hills, to scattered mountains and rocky headlands, and is interspread with numerous lakes.

The predominate landscape series is rolling hills with the remaining in steep hill•. Two-thirds of the Area's land-use consists of forest-wildland units and one-third of forest-town units. The significant amounts of inland water surfaces are scattered throughout both units. The entire Area has high visual quality. The coastline is the most rugged of the entire N.A.R. and, except for the Arcadia National Park, the majority of it is unprotected.

Early settlers, including fur traders, established settlements along the coastal inlets and along the main streams. Early agriculture was of a subsistence type while later agricultural development supported the dairy industry. The twentieth century has shown declines in agriculture and forestry and increases in manufacturing in the Area.

The population of the Area in 1960 was 157,698 with a density of 25 people per square mile. Sub-area a had a population of 9,802 with 10 people per square mile, while sub-areas b's population was 147,900 with 28 people per square mile. The population for the entire Area is projected to reach 240,200 by 2020.

Per capita income was 75 percent of the national average in 1959 and is projected to increase to 80 percent by 2020.

The 1960 employment of 52,275 is expected to increase to 92,300 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; agriculture, forestry and fisheries; and contract construction. Employment is expected to decrease in agriculture, forestry and fisheries; and mining

There is an ample supply of fresh water in the Area. Water quality problems exist to a limited extent as a result of some effluent discharges into coastal streams. Pollution is less severe here than in the other Areas of Maine. There are numerous reservoirs scattered throughout the Area which are used mainly for hydroelectric power generation and water recreation purposes, which have little regulatory effect on average monthly runoff.

Average annual runoff in Area 5, including drainage from about 625 square miles in Canada, is approximately 7,510 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,465 m.g.d., and the corresponding seven-day minimum is about 70% of this total or 1,020

m.g.d. (See Appendix C). The addition of 9 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 1,029 m.g.d., or 14% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 2,582 m.g.d., or 34% of the average runoff. Considering the U.S. portion only, the practical limit would be equivalent to about 36% of the average runoff. Potential sources which would develop the increase of 1,553 m.g.d., include major storage, accounting for 24% of the increase; upstream storage, 58%, and ground water development, 18%.

Possible Alternative Planning Objectives. Area 5 could support any combination of the three NAR planning objectives, though it would seem difficult to emphasize National Efficiency alone, without including Environmental Quality. The terrain is still quite wild and undeveloped, providing opportunities for recreational development and preservation of the Area's natural resources. Economic stimulation could be emphasized because of the Area's low income level. The very large differences of size and population between the two subareas could also affect the make up of the planning objective.

Recommended Mixed Objective. The recommendation for Area 5 is that the emphasis be placed on Environmental Quality with some Regional Development. R.D. would be emphasized to provide nonseasonal economic development for certain economically depressed portions of the Area, as well as for developement of the Area's recreational resources. Regional Development would help satisfy the Environmental Quality objectives since the environmental resources would have to be preserved and maintained for both.

Needs to be Satisfied. The most important needs in Area 5 are those associated with visual and cultural, water recreation, publicly supplied and industrial self-supplied water, and fish and wildlife. Industrial self-supplied water will have a high rate of growth to the year 2000. Non-agriculture irrigation and power plant cooling needs have high growth rates in the first time period. The other needs will have moderate but steady growth rates throughout the planning period. These needs will be critical in providing a high quality environment when portions of the Area are devoted to industrial development. Visual and cultural needs will involve the maintenance of unique shorelines, natural landscapes,as well as the preservation of some areas of high quality landscapes. Water recreation needs show moderate increases in visitor-days, stream and river miles, water surface and land facilities. Fish and wildlife needs show small increases in sport fishing and hunting man-days and hunting access and large increases in all types of fishing access.

Water quality maintenance needs will be equally important in achieving the mixed objective. Although these needs are not large,

they will double by each benckmark year and their satisfaction is key to attaining a high quality environment for the visual and cultural need. Power plant cooling water needs are important in Area 5 especially for meeting the Regional Development portion of the mixed objective. Fulfillment of this need will supply the energy required for regional growth and energy to export for regional income.

Needs for commercial navigation, upstream flood damage reduction streambank erosion, irrigation water and rural water supply are relatively small but, except for rural water supply, have high growth rates. Satisfaction of the irrigation and rural water supply needs will help preserve farm landscapes to increase the Area's income.

The Area's other needs range from the moderately sized drainage control and flood damage reduction to the small erosion control needs. These needs grow steadily throughout the planning period. Health needs are for disease free shellfish products and for water quality maintenance in fishing waters.

Devices. There will be heavy reliance on upstream storage in the early- and mid-time frames for agriculture irrigation water, flood damage reduction, and publicly supplied water needs, and for low flow augmentation. Withdrawal facilities such as fresh, brackish and ocean intakes and wells will satisfy additional needs of irrigation and publicly supplied water and provide for the needs of industrial self-supplied water, power plant cooling, and rural water supply. When the withdrawal facilities are combined with the required conveyance devices and water quality control facilities the water supply and quality will be adequate for projected increases in population and industry with proper regard to the needs for preserving and enhancing the environmental quality. No one device can be considered as most important since there are severe limitations in potential supplies. Wells, due to topographic conditions, generally have unsatisfactory yields and in many cases the waters have a high metal content. Additionally, due to the many small streams in this coastal Area the possibility of water re-use is extremely limited. Small towns on coastal sites have the biggest supply problems and some facilities for intrArea diversions will be necessary in order to effectively utilize the resources of the small, widely scattered streams for local needs.

Water/Land devices can meet the drainage and erosion control and navigation needs and can partially meet the flood damage reduction, water recreation, and visual and cultural needs. Mainstream flood damage reduction needs will require only flood plain management.

Meeting water recreation, navigation, and fish and wildlife needs will require improvements in overland transportation facilities, parking and trails and other facilities. Land control devices will mainly

consist of fee simple purchase, zoning and tax incentive subsidy. Land purchase should be undertaken in the early time frame so as to forestall future possibilities of the land being priced out of the Environmental Quality market. Biological devices are neither large nor important if other complementary facilities such as those for water quality control are implemented in a timely manner. Fish and wildlife needs and visual and cultural needs should be easily met by present resources.

Benefits. Benefits to visual and cultural, water recreation and fish and wildlife needs will be large as the recommended program preserves the Area's high quality landscape and natural resources. Meeting water quality standards will be very beneficial to this landscape preservation effort. Water quality maintenance needs are key to the natural resource related needs and especially to restoration of anadromous fish, such as the Atlantic salmon, which have stopped using many streams because of pollution. There will also be benefits from maintenance of existing anadromous fish populations, such alewives and smelt.

Publicly supplied and industrial self-supplied water needs will receive moderate benefits as they aid in the Area's industrial development. Power plant cooling water benefits will be large as a source of income to the Area as well as aiding the Area's industrial development.

Navigation benefits will be high since the access routes from the ocean to all the ports and harbors of other Areas in Sub-Region A go through Area 5.

Costs. Water Quality maintenance costs are high because of the inadequancy of present methods of treatment and the degree of treatment required to reach the present water quality standards. Visual and cultural costs will be fairly high in 1980 when implementation of land management devices will be important so that future needs can be met at lower costs than will prevail later in the planning period. Power plant cooling costs will be high in 2020 when additional cooling devices compatible with the environment will be necessary to supply energy needs.

There may be costs to fish and wildlife needs due to possible adverse effects of power plant cooling water on aquatic life. These effects, however, are presently under investigation, by the Bureau of Sport, Fisheries and Wildlife and the State of Maine. Navigation costs will be relatively high, due mainly to channel improvements.

Alternative Programs. If Environmental Quality were emphasized, the rising trend towards urbanization would be slowed. The needs to be satisfied for publicly supplied and industrial self-supplied water and commercial navigation would be reduced; those for power plant cooling water would be increased; and the manner in which the needs

would be satisfied for upstream flood damage reduction and visual and cultural. General improvements in commercial navigation would be reduced in favor of specific commodity related improvements to reduce the impact of navigation on the environment. This would be at the expense of reducing the level of general economic activity. Power plant cooling water would be limited to saline sources. Efforts would be made to achieve the best possible water quality. This would tend to limit industrialization but would also aid health needs and Environmental Quality related needs by use of nutrient control and storm water discharge control. Visual and cultural needs would be gained through greater emphasis on outright purchases to avoid vacillations in public opinion which might jeopardize the effectiveness of the program over the planning period. Water recreation would have lower density participation by decreasing overland transportation and increasing the number and quality of facilities. This would reduce the environmental impacts and improve the recreational experiences, but at substantially greater costs.

If National Efficiency were emphasized, power plant cooling needs would increase substantially. The needs to be satisfied for navigation and erosion control would be slightly reduced and those for water recreation would be measurably reduced. Erosion control would be reduced because some of the results, such as improvements in visual quality, do not have monetary benefits. Improvements for navigation would be slightly reduced by delaying them until actually imperative. This would result in a reduction in the needs fulfilled with little harm to the National Income objective. Power plant cooling facilities would tend to be located closer to fresh or brackish water for reduced production costs. Much greater emphasis would be placed on structural measures for upstream flood damage reduction.

If Regional Development were chosen, the needs to be satisfied for forest drainage control and agriculture irrigation would be greatly increased; those for non-agriculture irrigation only slightly increased; and the manner in which power plant cooling, upstream flood damage reduction and visual and cultural needs would be met would differ. Forest drainage control would be increased several fold because it is a relatively simple and permanent device to increase productivity and enhance the landscape for recreation benefits. Agricultural irrigation would show large increases because of an overall greater emphasis on economic development. Power generation would be increased to strengthen industrial potential and constraints would be reduced on the use of fresh and brackish cooling water to reduce costs. Upstream flood damage reduction would be achieved primarily through structures rather than flood plain management to avoid reducing potential industrial sites. Greater emphasis would be placed on land purchase and easements for landscape maintenance in order to avoid general restrictions caused by legal controls.

AREA 5

NEEDS-cumulative	Pres.	MIXED OBJECTIVE		
		1980	2000	2020
Publicly Supplied Water (mgd)	13	17	23	33
Industrial Self-Supplied Water (mgd)	50	110	210	340
Rural Water Supply (mgd)	4.1	5.5	7.6	7.9
Irrigation Water: agriculture (1000 afy)	0.3	0.8	1.9	2.5
non-agriculture (1000 afy)	0.1	1.7	3.0	4.9
Power Plant Cooling: withdrawal, saline (cfs)	200	1400	7500	15300
brackish(cfs)	0	0	60	120
fresh (cfs)	0	0	0	10
consumption, brackish(cfs)	0	0	27	57
fresh (cfs)	0	0	0	5
Hydroelectric Power Generation (mw)	28	25	0	0
Navigation: commercial (m. tons annually)	1.1	1.5	2.8	5.4
recreational boating (1000 boats)	13	16	24	33
Water Recreation: visitor days (m.)	x	6.4	9.9	13.6
stream or river (miles)	x	38	48	65
water surface (1000 acres)	x	11	16	20
beach (acres)	x	150	190	200
pool (m. sq. ft.)	x	2.6	3.2	3.5
land facilities (1000 acres)	x	3.8	4.9	5.8
Fish & Wildlife: sport fishing man-days (m.)	1.7	1.8	2.1	2.5
surface area, lake (acres)				
stream(acres)				
access, fresh (acres)	x	13	41	73
salt (acres)	x	100	300	550
anadromous (acres)	x	20	28	36
piers (1000 feet)			x	x
hunting man-days (m.)	0.48	0.51	0.59	0.69
access (1000 sq. mi.)	x	0	0.15	0.35
nature study man-days (m.)	0.21	0.22	0.26	0.31
access (1000 acres)				
Water Quality Maint.: non-industrial (m. PEs)	0.16	0.18	0.21	0.24
industrial (m. PEs)	1.0	2.0	4.0	7.7
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	0.15	0.18	0.37	0.73
mainstream (m.$)	0.036	0.043	0.090	0.180
tidal & hurricane (m.$)	0.014	0.017	0.036	0.070
Drainage Control: cropland (1000 acres)	11	17	28	45
forest land (1000 acres)	x	0	8	32
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	110	120	130	130
urban (1000 acres)	370	380	400	410
stream bank (mi.)	x	1	4	7
coastal shoreline (mi.)	x	0	0	0
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural(sq.mi.)	90	490	490	490
unique shoreline (mi.)	90	490	490	490
high quality (sq.mi.)	x	1500	2600	3300
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	16	21	28	16	23	33	17	23	33
	110	190	270	110	200	300	110	210	340
				5.5	7.6	7.9			
	7.1	23.0	29.7	0.8	1.9	2.5	7.1	23.0	23.6
	2.0	3.3	4.9	1.7	3.0	4.9	1.8	3.2	4.9
	1300	8500	17800	1300	6200	12100	1300	6500	11200
	0	0	0	0	2330	6830	0	3000	9000
	0	0	0	0	0	750	0	0	750
	0	0	0	0	19	49	0	25	69
	0	0	0	0	0	7	0	0	7
				25	0	0			
	1.3	1.8	2.6	1.4	2.5	4.4	1.5	2.8	5.4
				16	24	33			
	6.3	9.6	13.6	5.5	8.4	12.7	6.4	9.9	13.6
	28	48	82	26	32	44	38	48	65
	20	29	39	6	8	11	11	16	20
	190	240	270	50	70	80	150	190	200
	3.3	4.1	4.6	1.0	1.3	1.6	2.6	3.2	3.5
	10.8	13.9	17.1	2.0	2.6	3.4	3.8	4.9	5.8
				1.8	2.1	2.5			
				13	41	73			
				100	300	550			
				20	28	36			
				0.51	0.59	0.69			
				0	0.15	0.35			
				0.22	0.26	0.31			
				0.18	0.21	0.24			
				2.0	4.0	7.7			
				0.18	0.37	0.73			
				0.043	0.090	0.180			
				0.017	0.036	0.070			
	17	28	45	15	24	38	17	28	45
	0	16	64	0	16	64	16	64	207
	120	130	130	120	120	120	120	130	130
	380	400	410	380	390	390	380	400	410
	3	8	13	1	2	3	1	4	7
	23	45	45	0	0	0	0	0	0
	x	x	x	x	x	x	x	x	x
	490	490	490	490	490	490	Same	as	EQ
	490	490	490	490	490	490	Same	as	EQ
	1100	2200	3300	1100	2200	3300	Same	as	EQ

AD-A036 617 CORPS OF ENGINEERS NEW YORK NORTH ATLANTIC DIV F/G 8/6

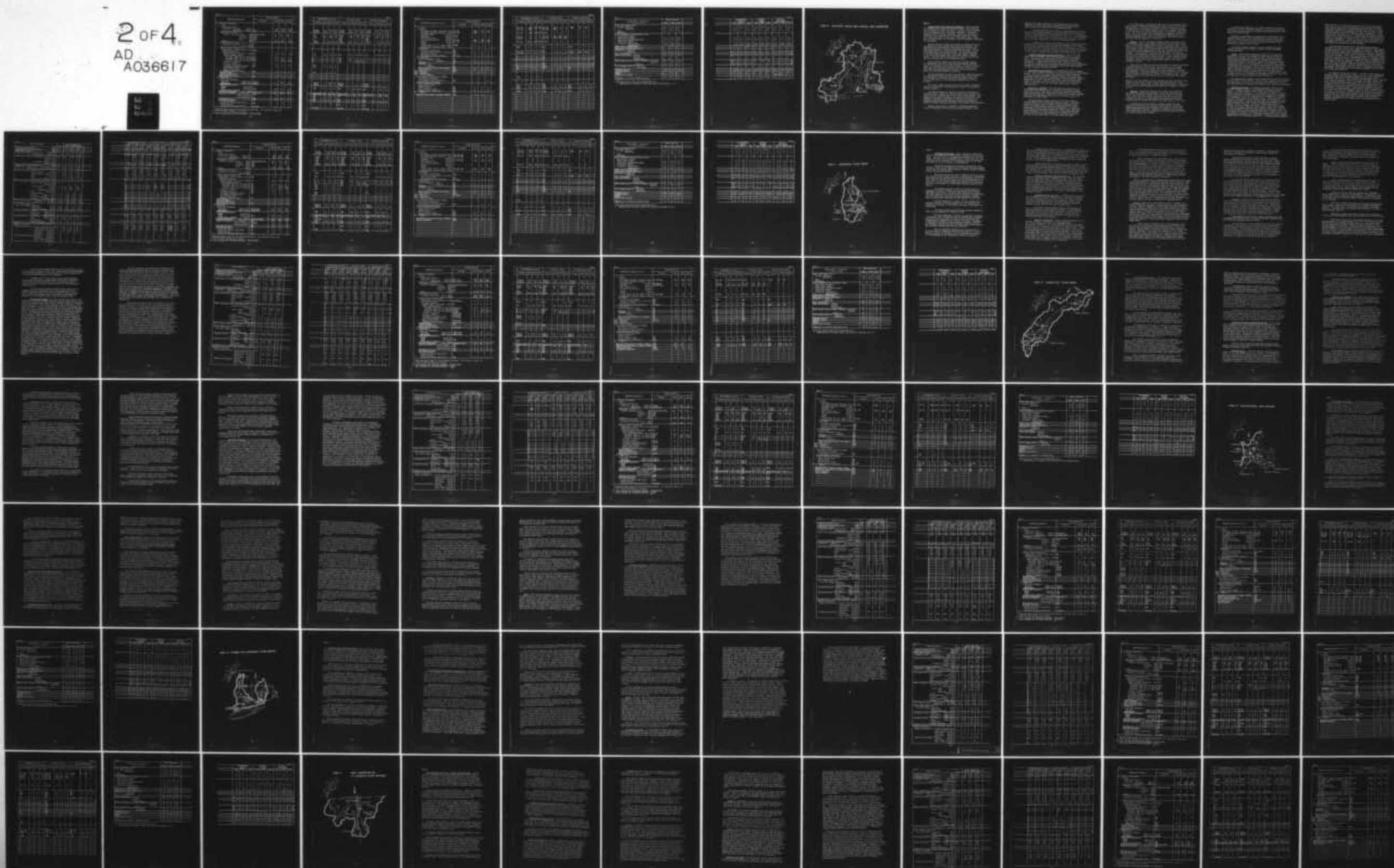
NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. ANNEX 1.(U)

MAY 72

UNCLASSIFIED NL

2 OF 4

AD
A036617



AREA 5

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)		4.8*	10.0*	51.2*
mainstream (1000 af)	WQ	0*	x*	x*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Irrig	56	97	122
brackish (mgd)	Ind	19	35	37
estuarine (mgd)	Pow		x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		4.0*	4.0*	5.5*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow		x	x
chemical/biological				
potable water treat plants (mgd)	PS	3.5	2.8	5.9
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	1.9	0	0
secondary (90%) (m. PE removed)	WQ	0	3.8	7.2
advanced (95%) (m. PE removed)	WQ	0	0.21	0.40
effluent irrigation				
nutrient control	WQ	x	x	x
stormwater discharge control	WQ	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ	x	x	x
Pumped Storage				
Desalting Facilities				
Monitoring Facilities	WQ	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	1	104	62
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	1.3	2.7	0.5
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	340	680	680
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav		x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig.

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	5.1	11.9	5.0	Irrig	0.4	0.8	0.5	Irrig	5.1	11.9	0.5
PS,WQ	5.8	x	0.6	PS,WQ	5.8	x	0.9	PS,WQ	7.7	x	0.9
**	52	78	81	Pow**	52	87	103	Pow**	56	97	122
Ind	18	28	23	Ind	18	32	31	Ind	19	35	37
				Pow		x	x	Pow		x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	7.5	11.3	8.4	Rur**	5.8	9.7	9.2	Rur**	7.6	12.7	10.1
PS	2.6	2.4	4.1	PS	2.6	3.3	5.9	PS	3.5	2.8	5.9
				WQ	1.9	0	0				
				WQ	0	3.8	7.2				
				WQ	0	0.21	0.40				
WQ	x	x	x								
WQ	x	x	x								
WQ	x	x	x								
FDR,VC	1	104	62	FDR,VC	1	x	x	FDR,VC	1	x	x
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	0	0	0	FDR	0	4.0	4.0	FDR	0	8.0	1.0
FDR,DrnVC	340	680	680	FDR,Drn,VC	x	150	40	FDR,Drn,VC	x	190	30
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x								
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav		x	x	Nav		x	x
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 5

DEVICES-incremental (cont.)	MIXED OBJECTIVE				
	Purposes	1980	2000	2020	
C. Land					
Controls					
fee simple purchase (buying)(sq.mi.)	VC, FW	500	200	100	
fee simple purchase (buying) (mi.)	VC, FW	400	0	0	
purchase lease (sq.mi.)					
easements (sq.mi.)	VC,FW	0	0	0	
deed restrictions (sq.mi.)					
tax incentive subsidy (sq.mi.)	VC, FW	700	450	300	
zoning (sq.mi.)	VC, FW	700	450	300	
zoning (mi.)					
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0	
zoning and/or tax inc. subs. (mi.)					
Facilities					
recreation development	Rec	x	x	x	
overland transportation to facility	Rec	x	x	x	
parking and trails	FW	x	x	x	
site sanitation and utilities	VC, Rec	x	x	x	
D. Biological					
Habitat Management, fish	FW	x	x	x	
wildlife	FW	x	x	x	
Fishways	FW	x	x	x	
Stocking, fish					
wildlife	FW	x	x	x	
Water Quality Standards Enforcement	FW	x	x	x	
Insect Control	Hlth	x	x	x	
II. Research	WQ		x		
III. Education					
IV. Policy Changes					
Water Demand and Allocation Changes					
pricing and rationing					
non-condenser power facilities	Pow			x	
re-circulation (internal)					
Project Operational Changes					
remove restrictions					
remove project	FW	x	x	x	
add new project needs	Rec	x	x	x	
change project design load	Rec	x	x	x	
V. Others					
Upstream Flood Control Storage (1000af)	FDR	11	24	4	

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	750	350	350	VC, FW	400	0	0	Same	as	EQ	
VC, FW	400	0	0	VC, FW	400	0	0	"	"	"	
VC, FW	350	350	350	VC,FW	0	0	0	"	"	"	
VC, FW	0	0	0	VC, FW	550	550	550	"	"	"	
VC,FW	0	0	0	VC, FW	550	550	550	"	"	"	
VC, FW	400	400	400	VC,FW	0	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC, Rec	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
Pow			x								
				FW	x	x	x				
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	0	58	12	FDR	0	70	7

AREA 5

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	0.2*	0.4*	2.1*	
mainstream	0*	0*	0*	
wells	2.3*	2.1*	3.1*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	3.2	3.7	6.0	
industrial self-supplied water	0.40	0.71	0.86	
rural water supply	x	x	x	
irrigation, agriculture	0.06	0.32	0.17	
nonagriculture	1.21	0.88	1.36	
Power Plant Cooling Water	0	19	73	
Hydroelectric Power Generation				
Navigation: commercial	0	6	8	
recreation	0.2	0.6	0.7	
Water Recreation	0.4	0.2	0.3	
Fish and Wildlife: fishing	0.52	0.63	0.73	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	100	200	380	
advanced	0	43	82	
other †	19	0	0	
Flood Damage Reduction: upstream	0.5	0.9	0.2	
mainstream				
Drainage Control	0.20	0.50	0.96	
Erosion Control	1.2	1.4	0.8	
Health	x	x	x	
Visual and Cultural	37.5	13.0	6.5	
Summation of Available Estimated Costs	170	280	570	

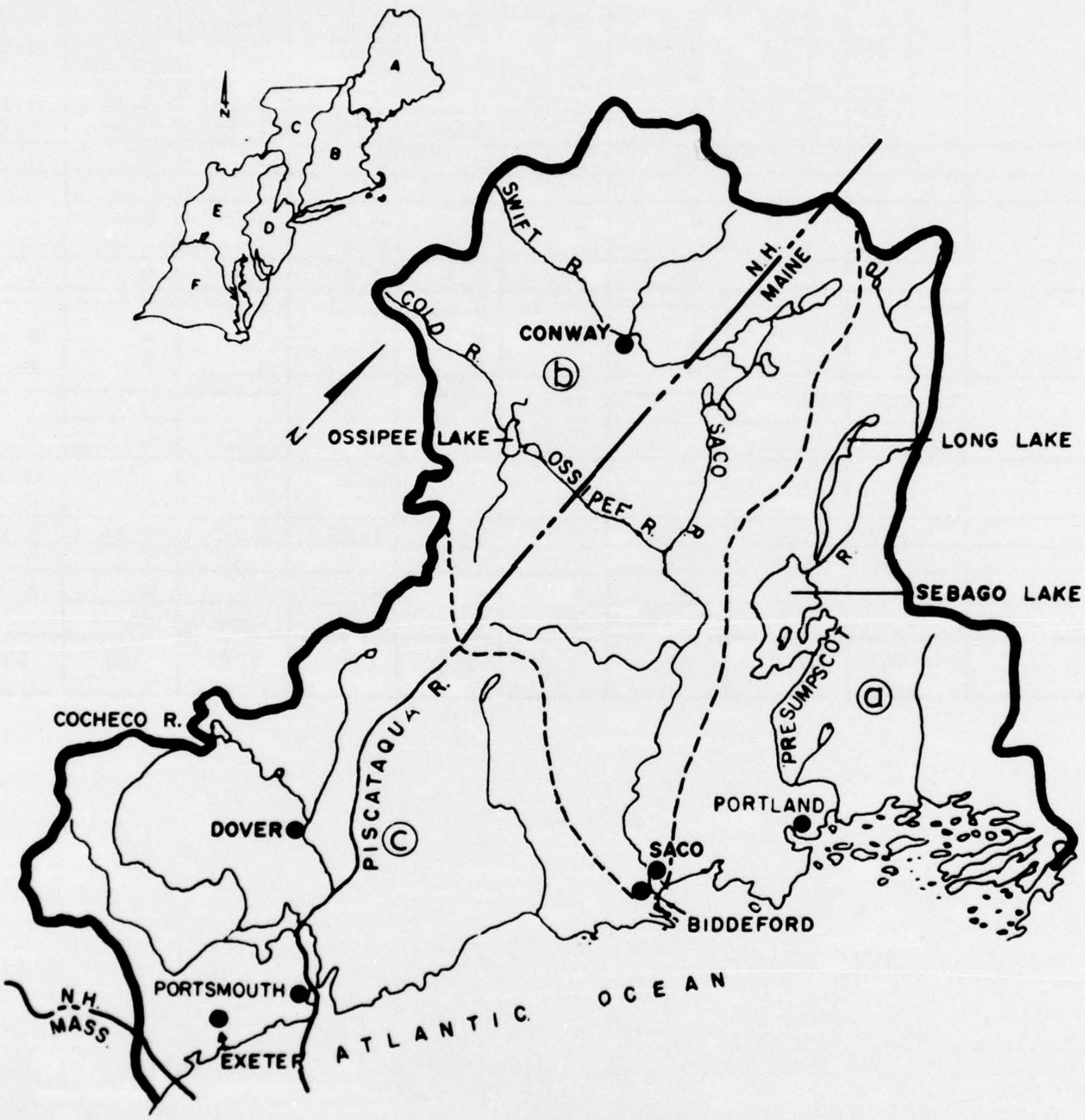
***From the supply model and includes OMR costs.**

† Combined sewer overflows control and acid mine drainage control.

AREA 5

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.3 1.6 0.9	0.8 0 1.2	0.4 0.4 1.3	0.02 1.6 0.8	0.08 0 1.1	0.05 0.6 1.5	0.3 2.2 0.9	0.8 0 1.3	0.05 0.6 1.7
	2.4 0.38 x 1.23 1.30	2.2 0.57 x 3.16 0.88	5.3 0.56 x 1.38 1.27	2.4 0.38 x 0.06 1.21	3.9 0.63 x 0.32 0.88	6.0 0.73 x 0.17 1.36	3.2 0.40 x 1.23 1.24	3.7 0.71 x 3.16 0.90	6.0 0.86 x 0.17 1.30
	0	3	86	0	0	0	0	3	5
	0	0	0	0	6	8	0	6	8
	←			0.2	0.6	0.7			→
	1.3	8.5	14.3	0.2	0.1	0.2	0.4	0.2	0.3
	←			0.52	0.63	0.73			→
	x x	x x	x x	x x	x x	x x	x x	x x	x x
	←			100	200	380			→
	←			0	43	82			→
	←			19	0	0			→
	0	0	0	0	2.1	0.7	0	2.8	0.3
	0.20	0.63	1.36	0.13	0.57	1.26	0.47	1.16	2.95
	46.8	45.1	0.9	0.8	1.0	0.5	1.2	1.4	0.8
	x	x	x	x	x	x	x	x	x
	72.5	41.5	41.5	0	0	0	Same as EQ		
	250	360	620	130	260	480	200	310	530

AREA 6 SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE



AREA 6

Southern Maine and Coastal New Hampshire. Area 6 includes the southern tip of Maine and the whole coast of New Hampshire and is divided into three sub-areas. Sub-area a is the drainage of the Presumpscot River and adjacent coastline. Sub-area b consists of the Saco River drainage. Sub-area c includes the Piscataqua River drainage and its adjacent coastline. There are 4,208 square miles in the Area. Lake Sebago, which covers over 20 square miles, is in Sub-area a and is extensively developed for recreation.

About 50 percent of the Area consists of rolling hills with the remainder divided between steep hills and mountains. The land-use pattern distribution is farm-forest and forest-town with lesser amounts of forest-wildland and city units. The upstream portions of the forest-wildlands are protected as part of the White Mountain National Forest. The overall landscape is of high visual quality with a very small amount of medial quality. The high quality farm-forest is the only significant area of this type east of the Connecticut River.

Early settlers cleared the land along the major streams for agriculture. The naval stores and wood products industry grew as a by-product of this land clearing. By 1800 the coastal areas were fairly densely populated. Portland, Maine, is the most developed urban area north of Boston and is serviced by rail, air, road and navigation facilities.

The 1960 population of Area 6 was 456,810. Population density for the Area as a whole was 109 people per square mile, while the population per square mile for the sub-areas is 183 in a, 44 in b, and 131 in c. The projected population for 2020 is 917,000.

Per capita income was 94 percent of the national average in 1959 and is projected to increase to 99 percent of the national average by 2020.

The 1960 employment of 175,000 is expected to increase to 328,600 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; transportation, communication and public utilities; and contract construction. Employment is expected to decrease in agriculture, forestry and fisheries; food and kindred products; textile mill products; apparel and other textiles; and lumber, wood products and furniture.

Overall, fresh water is available in adequate quantities in Area 6. Significant water quality problems presently occur,

however, from waste discharges in the Presumpscot River below Westbrook, the Saco River below Steep Falls, and Mousam River below Sanford and along most of the Piscataqua River.

Average annual runoff in Area 6 is approximately 4,615 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 655 m.g.d. and the corresponding seven-day minimum is about 77% of this total, or 578 m.g.d. (See Appendix C). The addition of 18 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 596 m.g.d., or 13% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,889 m.g.d., or 41% of the average runoff. Potential sources which would develop the increase of 1,293 m.g.d., include major storage, accounting for 33% of the increase; upstream storage, 52% and ground water development, 15%.

Possible Alternative Planning Objectives. Area 6 is a high visual quality forested region which is developing at a steady pace. Even though there are three sub-areas, the Area's population is fairly evenly distributed and the terrain is similar throughout. A single mixed objective can be applied to the whole Area and any combination of the three NAR objectives can be considered. An emphasis on recreational development around Lake Sebago should probably accompany any objective mix.

Recommended Mixed Objective. The recommended mixed objective for this Area is National Efficiency, strongly augmented by Environmental Quality. This mix will support the diversification of industry in the more densely populated southern portions of the Area while conserving those sections of particularly high environmental quality. Development of water recreation facilities, particularly on Lake Sebago in sub-area a, will not only help satisfy the recreational needs of this Area, but will also help attract users from surrounding Areas.

Needs to be Satisfied. The most important needs to be met include publicly supplied water, industrial self-supplied water, rural water supply, power plant cooling and commercial navigation. Meeting these needs will efficiently provide for the Area's expected industrial and population growth and, in the case of power, for some export to other Areas.

The Environmental Quality portion of the mixed objective can be primarily met by fulfilling irrigation water, visual and cultural, erosion control and water quality maintenance needs. Visual and cultural needs include the preservation of a large percentage of the coastline and the maintenance of at least half of the existing high quality landscape. Other needs, including water recreation, fish and wildlife, flood damage reduction and drainage control are of less importance to the mixed objective but will aid the fulfillment of the more important needs.

Most needs have a steady growth rate over the study period. Those needs that grow rapidly are power plant cooling, fresh and salt water fishing access, industrial self-supplied water, recreational boating and maintenance of landscape quality. Rural water supply will decline in the last period as central systems begin to consolidate some rural areas. Fish and wildlife needs are especially dependent upon meeting water quality maintenance needs especially for anadromous fish and coastal commercial fish, clams and crustaceans. The latter two fisheries are the most important in this Area.

Devices. Much of the publicly-supplied water, industrial self-supplied water, rural water supply and irrigation water needs will be met by direct fresh, brackish and estuarine intakes and wells. These facilities should be supplemented by some storage where there are local deficiencies. Power plant cooling needs will be satisfied primarily by using ocean intakes supplemented by estuarine, brackish and fresh water intakes. Cooling facilities will be used throughout the planning period and non-condensing facilities will be used in the later planning periods as the power plant cooling need grows. Waste treatment plants and almost every other form of water quality control facility will be necessary to meet water quality maintenance needs in this Area's population centers.

Visual and cultural needs will be satisfied by a variety of devices including easements, zoning and/or tax incentives and fee simple purchase. The visual and cultural needs will be aided by Water/Land management devices, including flood plain management and watershed management. Watershed management, erosion protection and drainage practices will also be used for erosion and drainage control. Any upstream storage in the Area will be used to aid upstream flood damage reduction.

Navigation and the smaller fish and wildlife and water recreation needs will not be difficult to meet through their basic devices. These devices include, respectively: general channel improvements; land acquisition and biological management; and operational changes of storage devices.

Benefits. Substantial benefits will result from satisfying the needs for publicly supplied water, industrial self-supplied water, and power plant cooling since they are vital to the growth of the Area. The use of saline water and other cooling and non-condenser facilities for power plant cooling needs will produce large benefits by saving the brackish and fresh waters of the Area.

Satisfaction of water quality maintenance needs will also produce high benefits, by providing a better quality environment, enhancing water recreation resources, and helping to restore the Area's anadromous fish runs. Benefits to fisheries will be large from meeting water quality maintenance needs as present populations can be more extensively utilized.

Recreation is responsible for a large portion of the yearly income to the Area's permanent residents. Investment in this need will result in large benefits including additional benefits to the visual and cultural need.

Benefits to agriculture by meeting rural water supply and irrigation water needs, will be important since poultry and truck farming is fairly extensive in the southern portion of the Area. High quality visual and cultural needs will also benefit from meeting the irrigation water needs.

Structural measures needed to control erosion will bring fairly high benefits by helping to control serious streambank erosion problems.

Costs. Water quality maintenance costs will be high due primarily to the need for treatment of municipal and industrial waste where untreated waste loads are high. Navigation costs will be high to stimulate and enhance recreational boating and commercial navigation activities. Visual and cultural costs are fairly high because of the large amount of land involved. These expenditures will be for fee simple purchase and for legal methods of obtaining land easements. Power plant cooling costs will be high in the last time period to reduce the impact upon the Area's fresh and brackish water by using saline water for cooling and through the use of non-condensing facilities. Erosion control costs increase steadily and although they are among the smaller costs, they are important in meeting the Area's mixed objective.

Non-agricultural irrigation water costs will be small but necessary as golf courses become popular. Upstream flood damage reduction costs are significant in the first planning period and decrease to zero in the third period after meeting all needs that will give positive benefits.

Alternative Programs. If Regional Development were to be emphasized throughout Area 6, the recommended program would be designed to increase business opportunities and encourage above average industrial expansion. As a consequence the needs to be satisfied would show an increase in agriculture irrigation and commercial navigation in the last time period and significantly increased for power plant cooling and drainage control. There would be a change in the manner in which the needs would be satisfied for water quality maintenance. There would be slightly less emphasis on the needs for water recreation in all time periods especially for beaches, pools and streams and rivers. Power plant cooling needs and the use of fresh, brackish and estuarine intakes will increase to serve industrial growth and there will be a reduction in the use of cooling towers and con-condensing facilities to reduce costs. The development of navigation facilities will occur earlier in the planning period at a greater cost. Drainage of forest land would increase substantially for increased productivity. A slightly greater emphasis

would be placed on increasing recreation density by building more facilities on less land to encourage private recreation ventures. Water quality maintenance would become much more important in these recreation areas but less emphasis would be placed on water quality maintenance where industrial expansion might be inhibited. No use would be made of nutrient control, stormwater discharge control and separation of combined severs. A slightly greater emphasis would be placed on structures for upstream flood control to avoid restrictive flood plain management. Visual and cultural needs would be met with increased costs by less use of legal methods and zoning and/or tax incentives and increased use of land purchase.

If Environmental Quality were to be emphasized exclusively throughout the Area, the need for commercial navigation would greatly decrease because of the decreased emphasis on industry. Power plant cooling needs for saline water would decrease in the last two planning periods as industrial growth would slow down but brackish withdrawal needs would increase. Water quality maintenance needs would be higher in Maine to aid retention of environmental quality. Drainage control needs for cropland and forest lands would be slightly increased to aid maintenance of quality landscape. Visual and cultural needs would be met by less use of legal methods and zoning and/or tax incentives and more use of land purchase. The last change would be in the devices for upstream flood damage reduction to aid the maintenance of quality landscapes. More flood plain and watershed management would be used and no upstream reservoirs.

The emphasis of National Income in Area 6 would produce the smallest changes from the mixed objective of any of the alternatives. Recreation needs would decrease slightly but the costs would be drastically cut as much fewer facilities and recreation areas - beaches, pools and water surface - would be provided for higher density use. Water quality maintenance needs would remain but would be met in a different manner as low flow augmentation would replace many of the devices such as nutrient control, storm water discharge control and separation of combined sewers. More upstream reservoirs and less flood plain and watershed management would be used to decrease costs. All types of erosion and irrigation needs and costs would be reduced and cheaper land controls would be used as the visual and cultural needs are met in a less costly manner. Power cooling costs would be reduced as brackish and fresh water withdrawal would increase; brackish consumption would increase and no non-condensing devices would be used.

AREA 6

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	50	65	97	143
Industrial Self-Supplied Water (mgd)	46	75	138	225
Rural Water Supply (mgd)	5.8	7.8	10.6	8.9
Irrigation Water: agriculture (1000 afy)	1.3	3.1	3.2	3.2
non-agriculture (1000 afy)	1.4	4.8	8.3	13.1
Power Plant Cooling: withdrawal, saline (cfs)	400	1600	7100	12300
brackish (cfs)	0	0	40	80
fresh (cfs)	0	0	0	30
consumption, brackish (cfs)	0	0	20	40
fresh (cfs)	0	0	0	14
Hydroelectric Power Generation (mw)	58	0	0	0
Navigation: commercial (m. tons annually)	32	48	78	119
recreational boating (1000 boats)	39	47	64	135
Water Recreation: visitor days (m.)	x	21	35	50
stream or river (miles)	x	160	210	300
water surface (1000 acres)	x	29	44	60
beach (acres)	x	500	660	760
pool (m. sq. ft.)	x	8.2	10.9	12.6
land facilities (1000 acres)	x	28	38	47
Fish & Wildlife: sport fishing man-days (m.)	4.2	5.2	6.4	7.9
surface area, lake (acres)				
stream (acres)				
access, fresh (acres)	x	70	200	360
salt (acres)	x	300	900	1600
anadromous (acres)	x	23	28	35
piers (1000 feet)				
hunting man-days (m.)	1.1	1.2	1.4	1.8
access (1000 sq. mi.)	x	0.10	0.55	1.00
nature study man-days (m.)	0.61	0.69	0.85	1.05
access (1000 acres)	x	0.3	0.6	1.2
Water Quality Maint.: non-industrial (m. PEs)	0.46	0.58	0.73	0.92
industrial (m. PEs)	0.59	1.04	1.69	2.81
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	1.3	2.1	3.7	7.6
mainstream (m.$)	0.4	0.7	1.4	3.0
tidal & hurricane (m.$)	0.03	0.05	0.09	0.19
Drainage Control: cropland (1000 acres)	10	13	21	24
forest land (1000 acres)	x	0	0	0
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	78	104	118	123
urban (1000 acres)	160	180	250	340
stream bank (mi.)	x	2	5	8
coastal shoreline (mi.)	x	1	3	5
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	850	850	850	850
unique shoreline (mi.)	x	60	60	60
high quality (sq.mi.)	x	700	1400	2100
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	63	86	119	65	97	143	66	98	145
	75	128	199	75	138	225	78	144	247
	←			7.8	10.6	8.9			→
	5.0	13.0	15.9	3.1	3.2	3.2	5.0	13.0	13.0
	5.5	8.9	13.1	4.8	8.3	13.1	5.0	8.6	13.1
	1600	4600	7000	1600	6300	12100	1600	6300	12100
	0	1100	1900	0	2300	5300	0	2300	4500
	0	0	60	0	0	800	0	60	160
	0	50	100	0	20	50	0	20	40
	0	0	20	0	0	14	0	26	53
	60	55	45	60	55	45	60	55	45
	40	65	103	48	78	119	52	84	127
	←			47	64	135			→
	21	35	50	19	30	47	22	36	50
	160	210	300	50	70	100	80	100	150
	55	84	115	15	23	32	29	44	60
	470	630	720	130	180	230	370	490	550
	8.2	10.9	12.6	2.6	3.4	9.4	6.4	8.5	9.4
	28	38	47	4	7	9	10	13	16
	←			5.2	6.4	7.9			→
	←			70	200	360			→
	←			300	900	1600			→
	←			23	28	35			→
	←			1.2	1.4	1.8			→
	←			0.10	0.55	1.00			→
	←			0.69	0.85	1.05			→
	←			0.3	0.6	1.2			→
	←			0.58	0.73	0.92			→
	←			1.04	1.69	2.81			→
	←			2.1	3.7	7.6			→
	←			0.7	1.4	3.0			→
	←			0.05	0.09	0.19			→
	15	25	27	13	21	24	15	25	27
	0	5	20	0	5	20	5	20	65
	105	120	123	95	103	104	104	118	123
	180	250	340	160	200	260	180	250	340
	3	9	15	1	3	5	2	5	8
	20	42	46	0	1	2	1	3	5
	x	x	x	x	x	x	x	x	x
	850	850	850	850	850	850	Same	as	EQ
	60	60	60	0	0	0	Same	as	EQ
	700	1400	2100	700	1400	2100	Same	as	EQ

AREA 6

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)		29*	64*	98*
mainstream (1000 af)		0*	0*	0*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	28	64	89
brackish (mgd)	Ind	15	8	20
estuarine (mgd)	Pow		x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		8.7*	10.5*	5.5*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	1.9	4.8	12.0
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	1.4	0	0
secondary (90%) (m. PE removed)	WQ	0	2.2	3.4
advanced (95%) (m. PE removed)	WQ	0	0.12	0.19
effluent irrigation	WQ	x	x	x
nutrient control	WQ	x	x	x
stormwater discharge control	WQ	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ	x	x	x
Pumped Storage				
Desalting Facilities				
Monitoring Facilities	WQ	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC,Rec	8.5	14.0	16.5
mainstream (1000 acres)	FDR,VC,Rec	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	2.5	4.5	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC,Rec	330	580	310
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig.

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	2.8	6.0	2.2	Irrig	1.4	0.1	0	Irrig	2.8	6.0	0
PS,WQ	3.9	6.0	3.4	PS,WQ	4.5	8.3	4.7	PS,WQ	4.8	8.3	4.8
Pow**	28	54	71	Pow**	28	64	89	Pow**	30	67	105
Ind	15	11	11	Ind	15	8	20	Ind	15	14	23
Pow		x	x	Pow		x	x	Pow		x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	10.1	13.1	13.0	Rur**	9.4	13.2	15.5	Rur**	10.2	15.1	15.4
Pow		x	x	Pow		x	x	Pow			x
PS	1.6	3.5	8.6	PS	1.9	4.8	12.0	PS	2.0	4.8	12.3
				WQ	1.4	0	0				
				WQ	0	2.2	3.4				
				WQ	0	0.12	0.19				
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
WQ	x	x	x								
WQ	x	x	x								
WQ	x	x	x					WQ	x	x	x
WQ	x	x	x								
FDR,VC	12	28	28	FDR,VC	5	x	5	FDR,VC	5	x	5
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	0	0	0	FDR	5.0	9.0	0	FDR	5.0	9.0	0
FDR,Drn,VC	310	620	620	FDR,Drn,VC	360	540	x	FDR,Drn,VC	360	540	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x								
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x		Nav	x	x	
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 6

DEVICES—incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW, Rec	150	150	150
fee simple purchase (buying) (mi.)	VC, FW, Rec	60	0	0
purchase lease (sq.mi.)				
easements (sq.mi.)	VC, FW, Rec	150	150	150
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW, Rec	400	400	400
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility				
parking and trails	FW	x	x	x
site sanitation and utilities	VC, Rec	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ, Hlth		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	46	55	0
Protect Shellfish	Hlth	x	x	x

	ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
	Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
	VC, FW	250	250	250	VC,FW	0	0	0	Same	as	EQ	
	VC, FW	60	0	0	VC,FW	0	0	0	"	"	"	
	VC, FW	250	250	250	VC, FW	250	250	250	"	"	"	
	VC, FW	200	200	200	VC, FW	450	450	450	"	"	"	
	Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
					FW	x	x	x				
	VC	x	x	x	VC	x	x	x	Same	as	EQ	
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					FW	x	x	x				
					Hlth	x	x	x				
	WQ		x		WQ		x		WQ		x	
	Pow			x								
					FW	x	x	x				
									Rec	x	x	x
	Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
	FDR	0	0	0	FDR	91	110	0	FDR	91	110	0

AREA 6

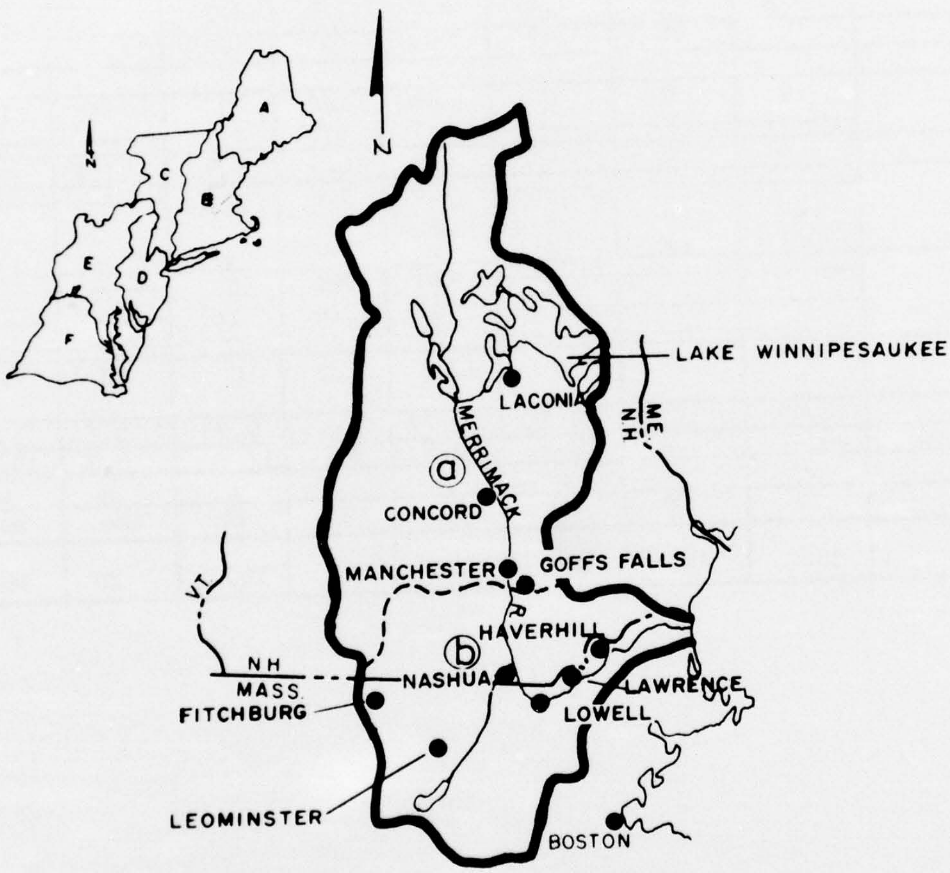
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE 1980	2000	2020	
Water Development Costs:				
storage, upstream	2.5*	5.4*	8.3*	
mainstream	0*	0*	0*	
wells	4.5*	5.8*	4.1*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	2.0	3.2	9.3	
industrial self-supplied water	0.23	0.38	0.57	
rural water supply	x	x	x	
irrigation, agriculture	0.14	0.03	0	
nonagriculture	2.9	2.6	3.5	
Power Plant Cooling Water	0	12	94	
Hydroelectric Power Generation				
Navigation: commercial	65	145	0	
recreation	4.1	3.5	5.4	
Water Recreation	10	18	48	
Fish and Wildlife: fishing	1.7	2.6	3.4	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	170	290	450	
advanced	0	26	38	
other ≠	97	0	0	
Flood Damage Reduction: upstream	6.6	3.8	0	
mainstream				
Drainage Control	0.27	0.71	0.27	
Erosion Control	6.3	15.2	18.5	
Health	x	x	x	
Visual and Cultural	39	22	22	
Summation of Available Estimated Costs	410	560	710	

***From the supply model and includes OMR costs.**

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.2	0.4	0.2	0.04	0.008	0	0.2	0.4	0
	1.2	1.5	0.8	1.4	2.1	1.1	1.5	2.1	1.1
	1.0	1.0	1.2	0.9	1.0	1.3	1.0	1.1	1.3
	1.9	3.0	7.5	2.0	3.2	9.3	2.0	3.2	9.4
	0.23	0.34	0.43	0.23	0.38	0.57	0.24	0.42	0.67
	x	x	x	x	x	x	x	x	x
	0.75	1.55	0.57	0.14	0.03	0	0.75	1.55	0
	3.2	2.5	4.1	3.0	2.6	3.5	3.0	2.6	3.4
	0	45	219	0	0	0	0	22	49
	0	0	0	65	145	0	65	145	0
	←			4.1	3.5	5.4			→
	10	18	48	0.9	0.5	0.8	1.8	0.8	4.3
	←			1.7	2.6	3.4			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			170	290	450			→
	←			0	26	38			→
	←			97	0	0			→
	0	0	0	13.3	7.5	0	13.3	7.5	0
	0.44	1.11	0.84	0.27	0.93	0.93	0.66	1.55	2.17
	43.4	54.4	22.5	0.8	9.1	12.0	6.3	15.2	18.5
	x	x	x	x	x	x	x	x	x
	53	36	36	16	16	16	Same	as	EQ
	390	490	840	380	510	540	420	560	620

AREA 7 MERRIMACK RIVER BASIN



AREA 7.

Merrimack River Basin. Area 7 consists of those portions of New Hampshire and Massachusetts drained by the Merrimack River. The Area covers 5,050 square miles divided into two sub-areas. Sub-area a is the drainage north of Goff Falls, N.H., and sub-area b is the remainder of the Merrimack Basin in New Hampshire and all of it is located in Massachusetts.

Glaciation has been the principal topographical force. Sub-area a tends to be mountainous and forested, with some subdued relief good for farming, while sub-area b has low relief of glacial outwash and morainal material.

More than half of the Area is composed of rolling hills with another third in steep hills and a lesser amount in mountains. The steep hills and mountains are in the northernmost part of the Area. Most of the Area is forest-town with some urbanization in sub-area b and some forest-wildland and farm-forest in sub-area a. About half of the Area is of high visual quality, mostly in sub-area a.

The northern sub-area a has high quality scenery, a developing recreation industry and some heavy industry around Manchester and Concord. Sub-area b and Manchester and Concord have been centers of the textile industry which has declined over the last twenty-five years and the food processing, chemical, paper and electronic industries are now dominant in the area.

The 1960 population of Area 7 was 1.23 million with a population density of 245 per square mile. The population is projected to increase to 2.19 million in 2020, or 400 people per square mile.

Per capita income was 6% above the national average in 1959, but will decrease to 3% above by 2020.

The 1960 employment of 490,305 is expected to increase to 965,800 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and transportation, communication and public utilities. Employment is expected to decrease in food and kindred products; textile mill products; apparel and other textiles; lumber, wood products and furniture; and petroleum and coal products.

Water is generally abundant in the Area but due to pollution from the industrial and population centers it is of a very poor quality in sub-area b and of a somewhat poor quality in the Winnipesaukee and Pemigewasset Rivers of sub-area a.

Average annual runoff in Area 7 is approximately 5,380 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 880 m.g.d., and the corresponding seven-day minimum is about 60% of this total, or 530 m.g.d. (See Appendix C). The addition of 45 m.g.d. as an allowance for consumptive losses and 95 m.g.d. developed for export to Area 9, results in an existing firm resource available for use of about 670 m.g.d., or 12% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 2,894 m.g.d., or 54% of the average runoff. Potential sources which would develop the increase of 2,224 m.g.d., include major storage, accounting for 56% of the increase; upstream storage, 32%, and ground water development, 12%.

Possible Alternative Planning Objectives. All three NAR planning objectives can be considered in Area 7, but the differences in topography, degree of development and population density would probably require different objectives for each sub-area. There is a need for preservation of quality landscapes and other natural resources in the Area because of the increasing pressures for recreational uses and because of the need for upgrading the area's degraded water quality. Because of these problems Environmental Quality should probably be included to some degree in any planning objective.

Recommended Mixed Objective. Different mixed objectives are recommended for each of the sub-areas. Sub-area a's natural and rural characteristics will best be aided by a mixed objective stressing Environmental Quality to preserve the quality of the resources in the headwaters but with some Regional Development emphasis to help raise the per capita income levels.

Sub-area b should emphasize Regional Development with some attention given to Environmental Quality. The RD emphasis would serve the developing urban, industrial, population and income growth in this area, and EQ emphasis in various enclaves along the major tributaries would help fill the esthetic and recreational needs of the populace.

Needs To Be Satisfied. Water quality maintenance is the key need of Area 7, this need is the most difficult and the most immediate of the water management problems in Area 7. This degree of importance is a result of the manner in which water quality acts as a constraint upon almost all uses of water. Growth in the industrial and the recreational activities of the Area requires maintenance of high water quality standards. While there is abundant water in Area 7, major diversions out of the Merrimack River Basin into nearby basins could adversely affect withdrawal needs within the Area itself by 2000. The meeting of these withdrawal needs will be hindered even sooner, especially in sub-area b, if water quality standards are not satisfied.

Flood damage reduction needs are important in sub-area b due to the existing quantity of development in the flood plains and to the insufficient although substantial control by structures of upstream portions of the Merrimack River.

Water recreation, fish and wildlife and visual and cultural needs will be especially important to sub-area a throughout the planning period of this study. High quality landscape maintenance and development is the most important part of these needs. Sub-area a will serve as a major source of activities connected with high environmental quality since its abundant resources of this type are very close to the large population centers of sub-area b. Fulfillment of these needs, however, will depend upon a large increase in accessibility to these resources of sub-area a. Development of metropolitan amenities is a large visual and cultural need in the urban portions of sub-area b.

Needs in the Area with an expected fairly high growth rate during the planning period are urban and stream bank erosion control, stream surface area for fish and wildlife, and fresh water consumption for power plant cooling. Hydroelectric power generation has a very high growth rate in the last two planning periods. Upstream flood damage reduction needs will also have high growth rates. Publicly supplied and industrial self-supplied water and non-agricultural irrigation needs have moderate growth rates. The other needs of Area 7 have steady,low or declining growth rates and include: rural water supply, commercial navigation, drainage control and agricultural erosion control. Health needs of the Area presently include recovery of the shellfish beds at and near the mouth of the Merrimack River.

Devices. Almost all of the different types of storage, withdrawal, conveyance and quality control facilities will be needed in the Area. The most important of these devices will be reservoirs, fresh and brackish intakes, wells, inter-basin diversions, cooling towers, waste treatment plants, nutrient control and separation of combined sewers. Effluent irrigation will also be used. These devices will enable the needs to be met that require water withdrawal and landscape and habitat improvements throughout the planning period. Reservoirs, wells and all of the quality control facilities will be especially necessary to provide the water required by 2000 for withdrawal needs.

Power cooling withdrawal needs in Massachusetts should be satisfied through ocean intakes combined with off shore outfalls so that the quality of the Area's fresh water will not be reduced. Health needs of sub-area b require the use of monitoring devices, especially if the shell fish industry is to be aided. Water quality control and separation of combined sewers are becoming increasingly important in sub-area a where the use of and settlement around recreational lakes are becoming more intense. Fish and wildlife needs can be met through land control and bio-

logical devices and also by removal of projects. Special attention will be required for anadromous fishing needs through the construction of fishways.

Land acquisition devices should generally be evenly applied throughout the planning period so that they can fulfill the visual and cultural and some fish and wildlife needs. Water/Land management devices can help meet the flood damage reduction, visual and cultural and water recreation needs, and can meet all of the drainage, erosion control and recreational boating needs. Flood damage reduction needs in this Area will require a mix of the Water/Land management devices. There is a resistance against reservoirs but significant upstream storage will be necessary along with flood plain management because of the large amount of settlement in the flood plains.

Recreational boating needs should be fulfilled with the help of new facilities that include ramps, berths and other mooring facilities in all planning periods. These activities will sufficiently raise the navigational capacity of the Area's waterways. Achievement of visual and cultural, drainage control and flood damage reduction needs will be aided through the use of watershed management during all planning periods. Drainage practices will also be necessary in fulfilling drainage control needs. Erosion control needs can be met through erosion protection and a good deal of river shoreline protection in the Massachusett's portion.

Benefits. Benefits will be very high from maintaining high water quality standards in the Area because of the existing large quantity of water pollution and because of the dependency of much of the Area's industry upon good quality water. These benefits are primarily economic and appear as reduced costs when meeting all of the Area's needs requiring water withdrawal. Maintaining high water quality will also produce high benefits for those instream needs which require specific standards of water quality including water recreation, fish and wildlife and health.

Flood damage reduction, water quality maintenance and the withdrawal needs are high after 2000 but can be met at reduced costs with the use of storage devices and wells.

The satisfaction of flood damage reduction, water quality maintenance, power plant cooling and hydroelectric power generation needs will allow sub-area b to be more competitive in attracting new industry. The meeting of other, less critical needs, such as water recreation, recreational boating, fish and wildlife and visual and cultural, will also aid in this effort of bringing industry to sub-area b by acting as an attraction to industrial work forces, in addition to raising the income of sub-area a.

Costs for meeting the visual and cultural needs of the Area will be reduced by multiple-purpose devices that are used for other needs including flood damage reduction, erosion control, water recreation, fish and wildlife, water quality maintenance needs and all water withdrawal associated needs which require the use of reservoirs.

Costs. Costs of fulfilling water recreation needs are large since recreation facilities are not well developed in sub-area a; since a great deal of care must be taken to provide the high quality recreational experience that is desired for the same sub-area; and since it is a difficult task to improve the quality of experience in the more populated sub-area b. Recreation costs are very large in the first time period of the study because of the immediate need to greatly improve facilities if any of the presently unfilled needs are to be satisfied.

Costs of meeting the water quality maintenance needs are very high because of the degree of treatment required. These costs will increase over the planning period as the industries and the populations grow, as new treatment methods are developed and introduced and as other, closely related, needs increase such as recreation, fish and wildlife and visual and cultural.

Devices for meeting publicly supplied water needs have fairly large costs in the last two time periods for acquisition and construction costs of reservoirs large enough to satisfy present and future needs and for tunnel and pipeline construction for transfers out of the Area.

Costs for fulfilling the visual and cultural needs are also fairly large. These costs are primarily for purchases and easements which are the primary means of successfully controlling landscape quality in this Area since other land control methods do not seem to provide enough incentive.

Rural water supply, agriculture irrigation, and drainage control costs are generally low for Area 7 because the needs are small.

Power plant cooling costs will become important in the final planning period of this Area because of the use of salt water cooling devices which would decrease thermal pollution of the Area's fresh water and because of the use of pipes for ocean outlets.that will do minimal damage to the ecology. Hydroelectric power generation costs will be increased as care is taken in the siting of each pumped-storage facility to keep it from detracting from the Area's visual and cultural resources. The increased costs will mitigate though not entirely stop the conflicts between visual and cultural needs and energy requirements.

Costs for flood damage reduction will be fairly high in the first two planning periods unless use is made of flood plain management. If flood plain management is not effective the size and quantity of structural devices will have to be increased.

Increases occur in the costs of water quality maintenance and the power plant cooling needs to aid in the fulfillment of the needs for water recreation, fish and wildlife, health, visual and cultural, publicly supplied water and industrial self-supplied water.

It will be very difficult to achieve the levels of investment that are recommended in this Area program for water quality maintenance and for the water recreation needs. A great deal of effort and pressure will be necessary to encourage the allocation of the necessary local, state and Federal funds.

Alternative Programs. If National Income were chosen to be emphasized in the Area's mixed objective, publicly supplied and industrial self-supplied water needs would be reduced slightly as population levels would fall. Agricultural irrigation needs would shift to the early time period so that the agricultural industry could become competitive sooner. Non-agricultural irrigation needs would be increased. Power plant cooling needs would become larger throughout the planning period. Brackish water would be used during the last planning period but the use of saline water would be decreased as fresh water use would increase. Fresh water consumption would also rise during the last two periods. The use of cooling towers and fresh and brackish intakes would be delayed until the last planning period. There would be no additional costs for power plant cooling. The need for water recreation would remain the same as the mixed objective program but there would be no need for new overland transportation to facilities. Water quality maintenance devices would not include nutrient control, storm water discharge control, cooling towers, septic tank control, separation of combined sewers, recycling of ground water and effluent irrigation. Upstream flood damage reduction would be achieved with less use of watershed management and less use of flood plain management and more local projects. Forest drainage control would be needed in the last two time periods which would raise the costs. Streambank and urban erosion control would be reduced as would the costs. Health needs for protection of shellfish would be eliminated as would monitoring ofheavy metals. The need for a high quality recreation experience in the Area would be reduced. This would allow for visual and cultural needs a decrease in the development of quality landscape; a small decrease in the development of metropolitan amenities in the first time period; no use of fee simple purchase; and an increase in the use of purchase lease easements and zoning and/or tax incentives. Costs to visual and cultural needs would be reduced greatly because of these changes.

Putting an emphasis upon Regional Development for the Area's mixed objective would mean an increase in all types of irrigation needs and costs to aid in the Area's economy. Power plant cooling needs would increase and cheaper means of meeting these needs would be used including more fresh water from river intakes and less use of cooling towers and lake, estuarine and ocean intakes. Recreation needs and costs would all increase to increase tourism. Water quality maintenance needs would remain the same but only treatment plants, mainstream reservoirs and research would be used to attain the need. Upstream flood damage reduction needs would be met by much less flood plain management and more upstream reservoirs and watershed management. Drainage control needs would increase, particularly for forests, and the costs would increase. Streambank erosion control needs and costs would decrease and shoreline erosion control needs would be eliminated. Visual and cultural needs would remain the same but would be met with less use of zoning and/or tax incentive and increased use of easements at a greater cost.

Environmental Quality could be emphasized in the entire Area, particularly in sub-area b, but only at great additional expense. Provision of a high quality landscape would require entirely new conceptual approaches towards what is necessary and acceptable for directly meeting the population's environmental quality needs in the urban setting. Design and preservation criteria, implementation methods and a willingness to pay would be difficult problems to solve. The Merrimack River goes directly through the urban centers and is part of the environment - cultural and landscape. This would require the River being brought up to the highest water quality standards at a very high cost. This would require decreased use of saline and fresh water withdrawals for power plant cooling except in the first planning period. Some other devices that can be used for emphasizing this objective include: reservoirs in urban parks; rehabilitated water fronts; natural treatment of drainage and flood control channels and of local flood protection projects; and the purchase of high quality landscape and cultural sites very close to the urban centers.

AREA 7

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	110	130	200	280
Industrial Self-Supplied Water (mgd)	100	120	210	350
Rural Water Supply (mgd)	4.8	5.6	5.8	5.2
Irrigation Water: agriculture (1000 afy)	2.8	3.8	6.0	5.9
non-agriculture (1000 afy)	6	10	15	20
Power Plant Cooling: withdrawal, saline (cfs)	0	0	300	3400
brackish (cfs)	0	0	0	0
fresh (cfs)	560	500	370	310
consumption, brackish (cfs)	0	0	0	0
fresh (cfs)	6	6	7	29
Hydroelectric Power Generation (mw)	70	80	490	1840
Navigation: commercial (m. tons annually)				
recreational boating (1000 boats)	50	67	93	165
Water Recreation: visitor days (m.)	x	51	83	125
stream or river (miles)	x	130	170	240
water surface (1000 acres)	x	40	60	80
beach (acres)	x	360	490	620
pool (m. sq. ft.)	x	7	10	12
land facilities (1000 acres)	x	14	19	25
Fish & Wildlife: sport fishing man-days (m.)	2.6	3.3	4.1	5.0
surface area, lake (acres)				
stream (acres)	x	900	2500	4400
access, fresh (acres)	x	68	182	316
salt (acres)				
anadromous (acres)	x	99	124	155
piers (1000 feet)				
hunting man-days (m.)	1.0	1.1	1.4	1.7
access (1000 sq. mi.)	x	0.20	0.65	0.70
nature study man-days (m.)	1.2	1.5	1.8	2.3
access (1000 acres)	x	3.7	9.0	15.9
Water Quality Maint.: non-industrial (m. PEs)	1.2	1.4	1.9	2.2
industrial (m. PEs)	0.8	1.3	2.5	4.4
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	2.4	3.7	7.0	14.2
mainstream (m.$)	4	6	12	25
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	8	10	16	20
forest land (1000 acres)	x	0	0	0
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	39	61	70	72
urban (1000 acres)	280	430	580	810
stream bank (mi.)	x	4	13	22
coastal shoreline (mi.)	x	4	8	8
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	410	410	410	410
unique shoreline (mi.)				
high quality (sq.mi.)	x	300	600	900
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	70	140	210
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	35	35	35

AREA 7

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	130	170	230	130	190	270	130	200	280
	120	190	280	120	200	320	120	210	350
				5.6	5.8	5.2			
	4.7	9.1	8.9	5.3	4.1	1.8	4.7	9.1	6.8
	15	24	35	13	22	35	13	23	35
	0	0	2300	0	0	800	0	0	800
	0	0	0	0	0	1700	0	0	1700
	550	350	100	550	950	1900	550	950	2600
	0	0	0	0	0	17	0	0	17
	6	4	40	6	10	52	6	10	55
				80	490	1840			
				67	93	165			
	58	94	133	51	83	125	60	98	133
	390	530	720	130	170	240	190	260	360
	140	220	300	40	60	80	80	120	150
	1300	1760	1940	360	490	620	1020	1380	1470
	23	31	34	7	10	12	18	24	25
	75	104	125	14	19	25	26	36	43
				3.3	4.1	5.0			
				900	2500	4400			
				68	182	316			
				99	124	155			
				1.1	1.4	1.7			
				0.20	0.65	0.70			
				1.5	1.8	2.3			
				3.7	9.0	15.9			
				1.4	1.9	2.2			
				1.3	2.5	4.4			
				3.7	7.0	14.2			
				6	12	25			
	12	20	23	10	16	20	12	20	23
	0	1	4	0	1	4	1	4	12
	61	70	72	54	61	62	61	70	72
	430	580	810	330	440	620	430	580	810
	4	13	22	1	3	5	2	6	10
	4	8	8	0	0	0	0	0	0
	x	x	x	x	x	x	x	x	x
	410	410	410	410	410	410	Same	as	EQ
	300	600	900	300	600	900	Same	as	EQ
	70	140	210	35	70	105	Same	as	EQ
	35	35	35	20	35	35	Same	as	EQ

AREA 7

DEVICES-incremental	MIXED OBJECTIVE Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	Rec, VC	0.9*	1.8*	427*
mainstream (1000 af)	Rec, VC,WQ	5*	175*	190*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	51	113	163
brackish (mgd)	Ind	11	15	14
estuarine (mgd)				
ocean (mgd)	Pow		x	x
wells (mgd)		3.0*	6.5*	6.3*
Conveyance Facilities				
interbasin diversions, into (mgd)		118*	100*	7*
out of (mgd)		118*	486*	743*
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ,Rec	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	17	40	34
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC,Rec	2.4	0	0
secondary (90%) (m. PE removed)	WQ,Rec	0	3.9	5.9
advanced (95%) (m. PE removed)	WQ,Rec	0	0.22	0.33
effluent irrigation	WQ,VC,Rec	x	x	x
nutrient control	WQ,VC,Rec	x	x	x
stormwater discharge control	WQ,VC,Rec	x	x	x
acid mine drainage control				
septic tank control	WQ,VC,Rec	x	x	x
separate combined sewers	WQ,VC,Rec	x	x	x
Pumped Storage	HPG		x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC,Rec	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC,Rec	17	20	55
mainstream (1000 acres)	FDR,VC,Rec	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	6	14	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC,Rec	370	740	740
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig.
ł Also includes the following purposes: VC,Rec

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	1.4	3.3	x	Irrig †	1.9	x	x	Irrig †	1.4	3.3	x
PS,WQ †	26	10	0.9	PS,WQ †	33	12	1.3	PS,WQ †	35	13	1.4
Pow**	45	88	107	Pow**	47	102	143	Pow**	51	113	163
Ind	13	7	10	Ind	11	14	9	Ind	11	15	14
				Pow			x	Pow			x
Pow			x	Pow			x	Pow			x
Rur**	17.4	27.8	31.0	Rur**	17.7	29.7	41.0	Rur**	18.0	32.7	43.6
Pow			x	Pow			x	Pow			x
PS	13	30	22	PS	16	38	32	PS	17	40	34
				WQ,VC	2.4	0	0				
				WQ	0	3.9	5.9				
				WQ	0	0.22	0.33				
WQ,VC	x	x	x								
WQ,VC	x	x	x								
WQ,VC	x	x	x								
				HPG		x	x				
FDR,VC	17	20	55	FDR,VC	10	5	15	FDR,VC	9	6	15
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	1	3	0	FDR	6	14	0	FDR	12	8	0
FDR,Drn,VC	370	740	740	FDR,Drn,VC	190	500	x	FDR,Drn,VC	560	120	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern		x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 7

DEVICES—incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW, Rec	260	220	220
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)	VC,FW,Rec	0	0	0
easements (sq.mi.)	VC, FW, Rec	75	75	75
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW, Rec	75	75	75
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC, Rec	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ, Rec		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	40	85	0
Mainstream Flood Control Storage (1000af)	FDR	11.4	2.4	0
Protect Shellfish	Hlth	x	x	x
Groundwater Recycling	WQ,Rec	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	260	220	220	VC,FW	0	0	0	Same	as	EQ	
VC,FW	0	0	0	VC, FW	55	50	35	"	"	"	
VC, FW	150	150	150	VC, FW	150	150	150	"	"	"	
VC,FW	0	0	0	VC, FW	150	150	150	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
				FW	x	x	x				
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	40	85	0	FDR	104	21	0
FDR	11.4	2.4	0	FDR	11.4	2.4	0	FDR	11.4	2.4	0

AREA 7

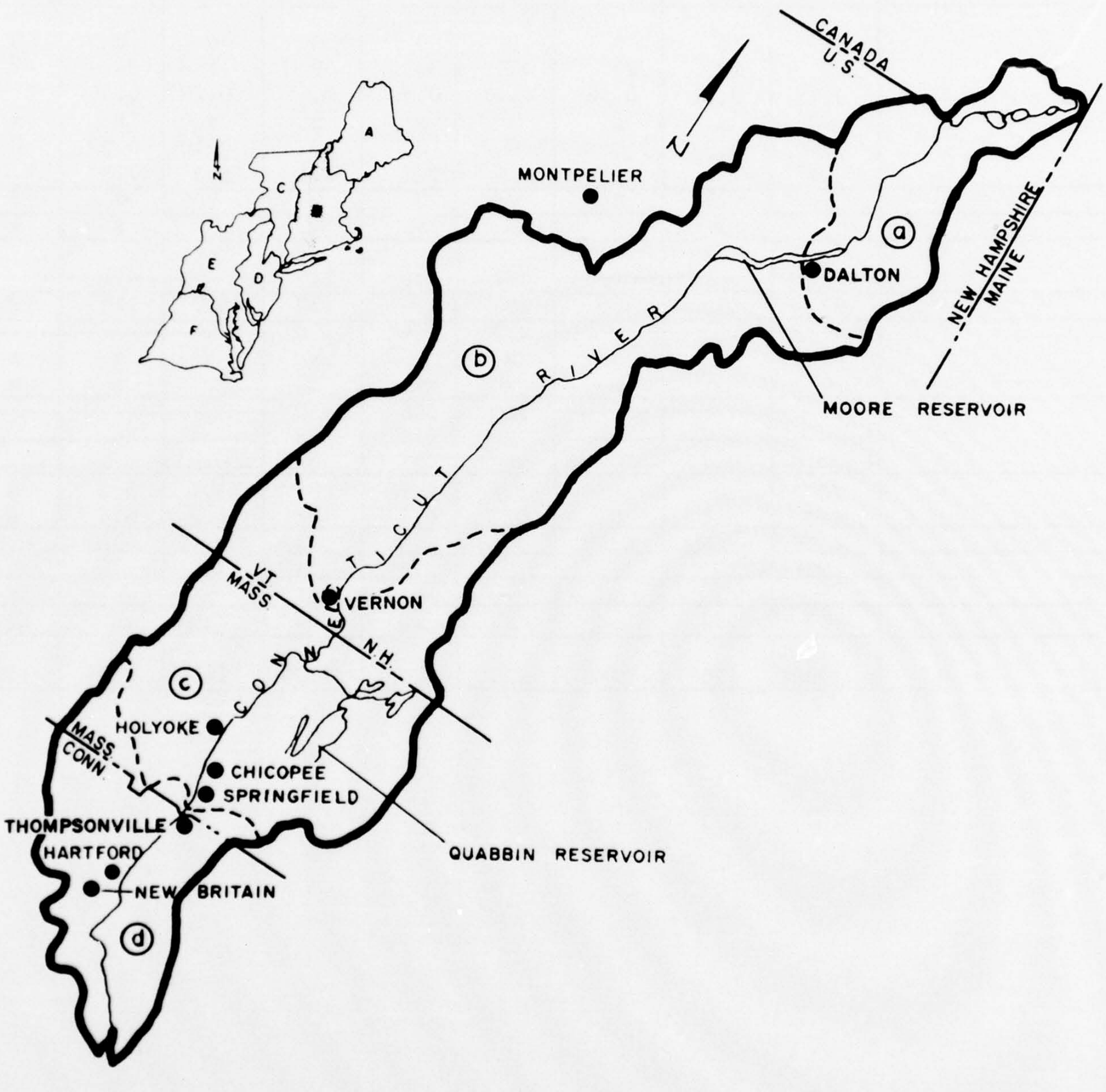
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE		
	1980	2000	2020
Water Development Costs:			
storage, upstream	0.2*	0.6*	73.3*
mainstream	3.9*	41.5*	29.6*
wells	1.8	3.5*	3.3*
desalting			
Water Withdrawal and Conveyance Costs:			
inter-basin transfers	76.6*	49.4*	3.9*
public water supply	12	34	42
industrial self-supplied water	0.29	0.56	0.77
rural water supply	x	x	x
irrigation, agriculture	0.20	0.46	0
nonagriculture	3.2	3.5	4.4
Power Plant Cooling Water	0	0	12
Hydroelectric Power Generation		x	x
Navigation: commercial			
recreation	0.7	0.8	1.4
Water Recreation	180	120	130
Fish and Wildlife: fishing	2.3	1.9	2.2
hunting	x	x	x
nature study	x	x	x
Water Quality Maint.: waste treatment, secondary	360	630	950
advanced	0	44	68
other ≠	260	0	0
Flood Damage Reduction: upstream	5.5	12.9	0
mainstream	4.3	6.4	0
Drainage Control	0.18	0.53	0.35
Erosion Control	32	33	36
Health	x	x	x
Visual and Cultural	51	45	45
Summation of Available Estimated Costs	1000	1000	1400

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.1	0.2	0	0	0	0	0.1	0.2	0
	5.9	2.6	0.7	7.7	3.3	1.0	8.1	3.4	1.1
	2.0	2.8	3.3	1.9	3.0	4.0	2.0	3.2	4.2
	0	0	0	0	0	0	0	0	0
	8	26	27	11	30	39	11	34	42
	0.28	0.41	0.52	0.27	0.50	0.65	0.29	0.56	0.77
	x	x	x	x	x	x	x	x	x
	0.40	0.92	0	0	0	0	0.40	0.92	0
	6.4	7.1	8.8	6.0	7.1	9.1	6.1	7.2	9.0
	0	26	34	0	0	0	0	0	8
		x	x		x	x		x	x
	←			0.7	0.8	1.4			→
	980	410	240	180	120	130	650	140	120
	←			2.3	1.9	2.2			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			360	630	950			→
	←			0	44	68			→
	←			260	0	0			→
	0	0	0	5.5	12.9	0	13.1	5.4	0
	4.3	6.4	0	4.3	6.4	0	4.3	6.4	0
	0.35	0.75	0.40	0.18	0.58	0.49	0.40	0.84	0.62
	32	33	36	9	18	28	24	24	36
	x	x	x	x	x	x	x	x	x
	58	52	52	28	28	24	Same	as	EQ
	1700	1200	1400	900	900	1300	1400	1000	1300

AREA 8 CONNECTICUT RIVER BASIN



AREA 8

Connecticut River Basin. The Connecticut River Basin drains 11,250 square miles and contains portions of Vermont, New Hampshire, Massachusetts, Connecticut and Canada. The 11,136 square miles of the basin in the North Atlantic Region is divided into four sub-areas: a is the portion above Dalton, N.H.; b is the area between Dalton and Vernon, Vt.; the portion between Vermont and Thompsonville, Conn. is c; and the remainder of the Area is d.

The major portion of this Area consists of steep hills with rolling hills and mountains comprising the remainder. Pattern distribution of the landscape is the most diverse in New England with over forty percent forest-town and lesser amounts of forest-wildland and farm forest. The combination of small town, village green, open agriculture bottomlands and hillside farms surrounded with wooded mountainside and crossed with streams provides a unique and exceptional landscape not found elsewhere within the NAR. The Area is almost evenly divided between high and medial visual quality.

Early settlement was established at Windsor, Conn. in 1633. Most of the good bottom land in the lower basin was cleared for agriculture by 1700. Early industries included saw mills, tanneries and textile and paper mills. Agriculture began to decline by the early 1900's. The present development phase shows a decline in agriculture and an increase in industrial expansion.

The population of the Area in 1960 was 1.6 million with the greatest concentration in sub-area d. Population density varies from 10 people per square mile in sub-area a to 527 people per square mile in d. The average population density of the Area is 147 people per square mile. The projected population in 2020 is 3.0 million. The largest cities of the Area are Hartford, in sub-area d, and Holyoke and Springfield in c.

Per capita income in 1960 was 6% above the national average and is expected to decrease to 4% above by 2020. The 1960 employment of 652,000 is expected to increase to 1.3 million by 2020. Industries with the largest 1960 employment include services, wholesale and retail trade; machinery; and finance, insurance and real estate. Employment is expected to decrease in agriculture, forestry and fisheries; textile mill products; apparel and other textiles; printing and publishing; and primary metals.

Water is normally abundant throughout the Area, except during low flow periods of the year, generally August and September. However, quality is seriously degraded in significant portions of the Area precluding the use of water for many purposes.

There are numerous natural and man-made impoundments, including extensive hydroelectric installations along the main stem of the Connecticut River. One intra-basin diversion of 22 m.g.d. exists in the Area from Quabbin Reservoir to Wilbraham, Mass., and surrounding towns. One inter-basin diversion of 195 mgd runs from Quabbin Reservoir to the Merrimack River Basin (Wachusett Reservoir).

A comprehensive study of water and related land resources of the basin has recently been completed by the Connecticut River Basin Coordinating Committee. The New England Division, Corps of Engineers, was the principal agency.

Average annual runoff in Area 8, including contributing drainage from 114 square miles in Canada, is approximately 12,230 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,400 m.g.d., and the corresponding seven-day minimum is about 60% of this total, or 1,425 m.g.d. (See Appendix C). The addition of 77 m.g.d. as an allowance for consumptive losses and 195 m.g.d. developed for export to Area 9 through Area 7, results in an existing firm resource available for use of about 1,697 m.g.d., or 14% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 5,159 m.g.d., or 42% of the average runoff. Potential sources which would develop the increase of 3,462 m.g.d., include major storage, accounting for 51% of the increase; upstream storage, 33%, and ground water development, 16%.

Possible Alternative Planning Objectives. It is possible to emphasize any one or combination of the objectives in this area. Because of the highly diverse landscape patterns and differing population densities of the Area a single emphasis in the mixed objective would probably be inappropriate. Environmental Quality should receive some emphasis in the mixed objective of this entire Area. The extensive landscape resources in this Area presently receive extensive recreation pressure in sub-areas c and d and increasing pressure in sub-areas a and b. These resources require preservation as the recreation pressure is expected to continue to grow and to rapidly expand.

There are also income and employment problems in sub-areas c and d that should probably receive some attention from the Regional Development objective.

Mixed Objective. Different objective mixes are recommended for the New Hampshire portion of Area 8. The New Hampshire portion of the Area should have a water resources management program that emphasizes Environmental Quality to adequately care for the region's pristine natural resources which are coming under increasing recreational use pressure. National Efficiency is recommended for emphasis to a lesser degree in this state, especially

for those parts of the water program which can not contribute directly to environmental improvement.

The water program in the Vermont, Massachusetts and Connecticut portions of the Area should give equal attention to Environmental Quality and Regional Development. Vermont has environmental and low employment problems that need assistance. The Massachusetts and Connecticut portions of the Area -- sub-areas a and b -- are closer to large population centers with the higher recreation use this entails. These two southern sub-areas are also becoming more densely populated and their sizeable local unemployment and low income problems must be solved.

Needs to be Satisfied. Water quality is already seriously degraded in many portions of the basin preventing the unrestricted use of water for many desirable and legitimate uses. The recommended mixed objective recognizes water quality maintenance as an important and key need for Area 8.

Water recreation, fish and wildlife, and visual and cultural needs will be important in all parts of the Area. High quality landscape maintenance, water access and development of new water surfaces are some of the most important types of these needs for the entire planning period. Fish and wildlife needs will grow rapidly throughout the planning period. An expanding population enjoying higher standards of living, more leisure time and improved transportation facilities will demand greater quantities of higher quality opportunities for recreation, fishing and hunting. There is an additional need for preserving unique natural and cultural sites in the early time frame to prevent them from being lost forever.

Publicly supplied water needs will be fairly small and industrial self-supplied water needs will be large in all time periods while their rate of growth will be above average. These needs, however, are required to meet thes demands of increased domestic use and industrial growth. Freshwater withdrawal for power plant cooling needs will grow very rapidly over the last two planning periods to meet these same demands. Commercial navigation and recreational boating needs will increase at a steady rate throughout the planning period as the population and the corresponding demands for good and services expand. Unique natural landscapes maintenances needs are very large and are essential in achieving the Environmental Quality objective.

Flood damage reduction needs will grow rapidly in each time period even though developments already completed have done much to alleviate flood damages. More upstream control and management will be required in the Area to protect agricultural and rural portions and the smaller urban centers. Mainstream controls and management are required to provide for the needs in sub-areas c and d where there is extensive existing flood plain development and only minor existing zoning restrictions.

Cropland drainage control, agricultural erosion control, and hydroelectric power generation needs have a fairly steady or declining level during the planning period but, nevertheless, will help strengthen the economy and improve the quality of the environment.

Devices. Water quality control facilities and water storage structures will be the most important devices in the Area in all time periods. These devices will include waste water treatment facilities with advanced treatment during the second and third phases of the planning period. Power plant cooling needs will require cooling towers while water quality maintenance needs will require storm water discharge control, separate combined sewers, interceptor sewers and nutrient control. Meeting these two needs would provide for the preservation and restoration of a desirable water habitat for water recreation, fish and wildlife, and visual and cultural needs.

Reservoir storage for low flow augmentation will be required to serve scattered pollution sources - such as agricultural runoff - especially in those portions of the Area where stream bank erosion and particular industrial effluent discharges do not allow for economic use of advanced waste treatment devices. Storage devices will also help fulfill the needs for public water supplies, flood damage reduction, and irrigation. Several reservoir sites should soon be preserved in this Area to assure their future availability. The application of such measures would provide opportunities for Area-wide development and timely use of resources for an expanding population. Additional water withdrawal needs for power plant cooling will be met by fresh, estuarine and saline intakes.

The most important device for flood damage reduction needs is some strategically located upstream storage concurrent with some upstream and mainstream flood plain management (which will also aid visual and cultural needs). Other Water/Land devices for flood damage reduction include local flood protection and upstream channel improvement during all of the periods. These actions should be able to meet the goal of controlling 25 percent of the drainage area above Hartford, Connecticut, as established by the Connecticut River Valley Flood Control Compact. Watershed management required for flood damage reduction, will also help fulfill drainage control, fish and wildlife and visual and cultural needs. Erosion protection will fulfill all of the erosion control needs.

The commercial navigation needs will be met by mainstream channel improvements. Recreational boating will also be aided by the channel improvements for commercial navigation as well as by new recreational boating facilities.

Visual and cultural needs, besides requiring the waste treatment devices of water quality maintenance, will be aided by the establishment of site facilities and the acquisition of land through purchases, easements and zoning and/or tax incentives. Fish and wildlife needs will be met through these same land acquisition devices in addition to obtaining access through parking facilities and trails and the use of all of the biological devices. Devices for bringing back the anadromous fisheries will be especially important and include fish habitat management, fishways and fish stocking. All of these devices - Water/Land, Land and Biological - will strengthen the Area's economy as well as improve the quality of its environment and preserve its natural beauty.

Water Recreation needs will be largely filled by planned reservoir storage, but will also need overland transportation to facilities and the changing of existing projects by adding new project needs, and changing project design loads.
Additional lakes will be available for recreation and other uses in the Area if means are found for eliminating the large sludge deposits that have accumulated in these lakes from logging and sawmill operations and pulp and paper plants. Existing water supply reservoirs could be used for water recreation if proper precautions, including potable water treatment, were taken.

Benefits. High benefits will be obtained by meeting the water recreation, fish and wildlife and visual and cultural needs under the recommended mixed objective. These needs will provide the desirable surroundings, recreational motivation and productivity of the fish and wildlife resource, important to the Area's mixed objective.

Benefits will also be high from providing publicly supplied and industrial self-supplied water to the southern part of the Area to help maintain its growth pattern. Flood damage reduction benefits should be fairly high, protecting both industrial and agricultural interests. Use of reservoirs for low flow augmentation provides multiple-use benefits such as for fish and wildlife (anadromous and resident fish habitat improvement), visual and cultural and water quality maintenance (dilution of pollution from diffused sources).

Extensive benefits will result from meeting water quality standards. This will aid in controlling the widespread pollution prevalent in many parts of the Connecticut River Basin.

Meeting of drainage control and power plant cooling needs, though less widespread, should also bring fairly high benefits by helping to support the economy of this Area.

Further redevelopment of the existing Quabbin Reservoir diversion will provide benefits to parts of Area's 9 and 7 with respect to all water withdrawal needs.

Costs. The very large water recreation costs are highest in the early years of the study when implementation is needed to preserve land for future use in order to satisfy this need. Water quality maintenance costs are highest later on in the planning period when high levels of advanced waste treatment are needed to keep abreast of the greater volumes of waste imposed on the system.

Visual and cultural device costs are also relatively large particularly in 1980 when fee simple purchases are used for maintaining unique natural landscapes before they become too expensive.

Power plant cooling costs are high in 2000 and 2020 to provide the cooling towers and non-condensing generation required to meet the objective mix. Costs will be high for publicly supplied water in about the year 2000 to provide for future population needs. Costs will also be high for non-agricultural irrigation needs as the population grows. Flood damage reduction needs will be high in 1980 and decline in 2000 and 2020 as strict flood plain management measures are instituted.

Industrial self-supplied water, power plant cooling and drainage control devices can have the effect of raising the costs of esthetic devices and thereby reduce benefits in satisfying the visual and cultural need.

Alternative Programs. If only Environmental Quality net benefits were chosen to be emphasized throughout Area 8, the needs to be satisfied for irrigation water would be significantly higher; drainage control would be slightly higher; power plant cooling shifts to saline withdrawal from fresh; commercial navigation should be lower; and those for upstream flood damage reduction would be satisfied in a different manner. Publicly supplied and industrial self-supplied water needs would be slightly lower. Drainage control and irrigation water needs should be increased because they generally improve environmental quality by providing landscape diversity and quality. About half of the power plant cooling needs would be diverted to other Areas because of substantially increased costs resulting from emphasis on non-condensing facilities and only token allowances for fresh water withdrawals for power plant cooling. This would reduce the impact of navigation and its devices on the environment without reducing the level of general economic activity. Reservoirs would not be used for upstream flood damage reduction which would be achieved entirely through flood plain management to increase the benefits to visual and cultural and fish and wildlife needs through increased preservation of natural flood plains.

If National Income were chosen to be emphasized throughout the Area, the needs to be satisfied for irrigation water, water recreation, and erosion control would be greatly reduced; those needs for power plant cooling would increase, particularly for fresh water withdrawal; and the manner in which flood damage reduction and visual and

cultural needs would be achieved would differ. Erosion control and irrigation water would be reduced because many of their benefits are aesthetic, such as improved landscape quality, and are not economically efficient. Minimum facilities and development would be pursued for water recreation, which would tend to reduce the quality of the recreation experience, and which in turn would result in lower numbers of recreators. Landscape quality would be achieved through zoning and tax incentives where possible to reduce costs. Flood damage reduction would be achieved by a greater emphasis on structures because of their potential for multiple use, their generally cheaper costs and the potential use of their flood plains by industry. Power plant cooling needs would be measurably increased as compared to the suggested program since constraints would be removed from the use of fresh water and costs for its use would decline.

If Regional Development were chosen to be emphasized throughout the Area, the recommended program would be designed to increase business opportunities and encourage above average industrial expansion. As a consequence the needs to be satisfied for commercial navigation, power plant cooling water and drainage control would be increased; those of streambank erosion control decreased; and those of power plant cooling, water recreation, and flood damage reduction achieved with a different mix of devices. Commercial navigation development would be accelerated to improve the local transportation network. Streambank erosion control would be reduced because of the reduced emphasis on environmental quality. Power plant cooling needs would be shifted from saline to the cheaper brackish and fresh water withdrawals. The use of expensive non-condensing facilities would be eliminated. and ocean intakes would be used only in the last time period. Costs would be greatly reduced as a result but some extra device costs would still be retained to aid environmental protection while the fresh and brackish water withdrawals and consumption increase. Water recreation would increase but be achieved at lower costs by construction of fewer land and recreational boating facilities. This would increase the density of recreators and the Area's economic return. Flood damage reduction would be achieved by less use of upstream flood plain and watershed management and projects and by increased use of upstream and mainstream reservoirs to avoid reduction of potential business sites in flood plains.

AREA 8

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	190	240	350	530
Industrial Self-Supplied Water (mgd)	300	500	900	1500
Rural Water Supply (mgd)	16	21	26	22
Irrigation Water: agriculture (1000 afy)	7	25	26	26
non-agriculture (1000 afy)	5	16	27	42
Power Plant Cooling: withdrawal, saline (cfs)	x	0	500	880
brackish (cfs)	1700	1500	2000	1400
fresh (cfs)	800	870	1100	2300
consumption, brackish (cfs)	16	15	19	15
fresh (cfs)	10	40	70	110
Hydroelectric Power Generation (mw)	600	2200	3900	7000
Navigation: commercial (m.tons annually)	3.8	4.6	6.8	10.2
recreational boating (1000 boats)	71	97	171	298
Water Recreation: visitor days (m.)	x	56	89	133
stream or river (miles)	x	440	580	820
water surface (1000 acres)	x	140	210	290
beach (acres)	x	1200	1600	2000
pool (m. sq. ft.)	x	21	28	34
land facilities (1000 acres)	x	71	96	125
Fish & Wildlife: sport fishing man-days (m.)	3.7	5.0	6.3	7.9
surface area, lake (acres)	x	1200	4900	8900
stream (acres)	x	2600	5200	8300
access, fresh (acres)	x	190	390	620
salt (acres)				
anadromous (acres)	x	43	57	76
piers (1000 feet)				
hunting man-days (m.)	1.4	1.8	2.2	2.8
access (1000 sq. mi.)	x	1.0	1.6	2.4
nature study man-days (m.)	2.2	2.9	3.7	4.6
access (1000 acres)	x	1.4	3.6	6.3
Water Quality Maint.: non-industrial (m. PEs)	1.6	1.9	2.3	3.1
industrial (m. PEs)	2.5	4.8	9.0	17.3
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	4	6	12	25
mainstream (m.$)	6	10	20	40
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	45	60	96	109
forest land (1000 acres)	x	0	5	20
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	330	400	440	460
urban (1000 acres)	540	800	1030	1370
stream bank (mi.)	x	10	30	50
coastal shoreline (mi.)				
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	500	3500	3500	3500
unique shoreline (mi.)				
high quality (sq.mi.)	x	700	1400	2100
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
230	310	430	240	340	520	240	350	530
500	800	1300	500	800	1400	500	900	1600
			21	26	22			
38	64	72	24	14	8	38	64	58
18	29	43	16	27	43	17	28	43
0	2000	3100	0	1000	1350	0	0	350
1600	1200	0	1600	2200	2500	1600	2200	2500
800	70	60	800	3400	6400	800	2100	2200
15	10	0	15	17	22	15	18	22
40	30	30	40	60	90	40	50	90
			2200	3900	7000			
4.4	5.9	8.0	4.7	7.3	11.2	4.9	8.0	12.9
			97	171	298			
56	89	133	49	77	123	57	91	135
440	580	820	150	190	270	220	290	400
140	210	290	40	60	80	70	110	150
1200	1600	2000	300	500	600	1000	1300	1500
21	28	34	7	9	12	17	22	26
71	96	125	13	18	24	25	33	44
			5.0	6.3	7.9			
			1200	4900	8900			
			2600	5200	8300			
			190	390	620			
			43	57	76			
			1.8	2.2	2.8			
			1.0	1.6	2.4			
			2.9	3.7	4.6			
			1.4	3.6	6.3			
			1.9	2.3	3.1			
			4.8	9.0	17.3			
			6	12	25			
			10	20	40			
68	113	125	60	96	109	68	113	125
0	5	20	0	5	20	5	20	65
400	440	460	350	370	370	400	440	460
800	1030	1400	620	750	940	800	1030	1400
10	30	50	2	7	12	5	15	25
x	x	x	x	x	x	x	x	x
3500	3500	3500	3500	3500	3500	Same	as	EQ
700	1400	2100	700	1400	2100	Same	as	EQ

AREA 8

DEVICES–incremental	MIXED OBJECTIVE Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec	25*	227*	x*
mainstream (1000 af)	FW,Rec,WQ	48*	54*	173*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	170	350	530
brackish (mgd)	Ind	4	6	7
estuarine (mgd)	Pow	x	x	x
ocean (mgd)	Pow		x	x
wells (mgd)		28*	11*	0*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)		118*	100*	7*
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	24	33	53
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC	5.7	0	0
secondary (90%) (m. PE removed)	WQ	0	10.2	18.3
advanced (95%) (m. PE removed)	WQ	0	0.57	1.02
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG	x	x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	15	19	18
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	3.5	2.5	1.5
flood control channels (mi.)	FDR	0	0.25	0
Watershed Management (1000 acres)	FDR,Drn,VC	440	680	620
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig.
∤ Also includes the following purposes: FW,Rec

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	23	20	6	Irrig †	13	x	x	Irrig †	23	20	x
PS,WQ †	6	109	2	PS,WQ,FW	7	141	3	PS,WQ †	8	149	3
Pow**	160	280	420	Pow**	160	320	520	Pow**	170	360	610
Ind	6	3	3	Ind	6	3	7	Ind	4	7	8
Pow	x	x		Pow	x	x	x	Pow	x	x	x
Pow		x	x	Pow		x	x	Pow			x
Rur**	56	81	105	Rur**	53	86	130	Rur**	59	99	145
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
PS	19	24	36	PS	24	31	50	PS	24	33	53
				WQ,VC	5.7	0	0				
				WQ	0	10.2	18.3				
				WQ	0	0.57	1.02				
WQ,VC	x	x	x								
WQ,VC	x	x	x								
WQ,VC	x	x	x								
				HPG	x	x	x				
FDR,VC	23	31	26	FDR,VC	6	6	10	FDR,VC	6	5	11
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	0	0	0	FDR	9.0	5.0	3.0	FDR	10.0	7.0	11.0
FDR	0	0	0	FDR	0	0.5	0				
FDR,Drn,VC	600	1210	1210	FDR,Drn,VC	270	160	30	FDR,Drn,VC	300	1160	250
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x			Nav	x	x	x	Nav	x	x	x
Rec,Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 8

DEVICES–incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying) (sq.mi.)	VC, FW	3350	0	0
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)	VC, FW	200	200	200
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs. (sq.mi.)	VC, FW	150	150	150
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions	Rec	x	x	
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	26	19	7
Mainstream Flood Control Storage (1000af)	FDR	240	0	0
Protect Shellfish	Hlth	x	x	x
Flood Skimming	Ind	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	3350	350	350	VC, FW	1500	0	0	Same	as	EQ	
VC, FW	350	350	350	VC, FW	350	350	350	"	"	"	
VC,FW	0	0	0	VC, FW	1850	350	350	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x									
Pow		x	x								
				FW		x	x				
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	52	38	13	FDR	59	45	47
FDR	0	0	0	FDR	450	0	0	FDR	450	0	0

AREA 8

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	5.8*	32.6*	0.0*	
mainstream	16.7*	9.1*	55.0*	
wells	14.9*	6.2*	0.4*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	12	19	29	
industrial self-supplied water	0.90	1.89	3.10	
rural water supply	x	x	x	
irrigation, agriculture	3.16	0.14	0.05	
nonagriculture	9.8	8.8	11.0	
Power Plant Cooling Water	0	33	57	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial	0	7	7	
recreation	0.5	1.7	2.9	
Water Recreation	720	350	430	
Fish and Wildlife: fishing	3.1	2.7	3.3	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	410	580	1040	
advanced	0	120	210	
other ≠	500	0	0	
Flood Damage Reduction: upstream	7.1	3.4	2.6	
mainstream	0	0	0	
Drainage Control	1.3	3.4	1.8	
Erosion Control	49	37	52	
Health	x	x	x	
Visual and Cultural	386	80	80	
Summation of Available Estimated Costs	2100	1300	2000	

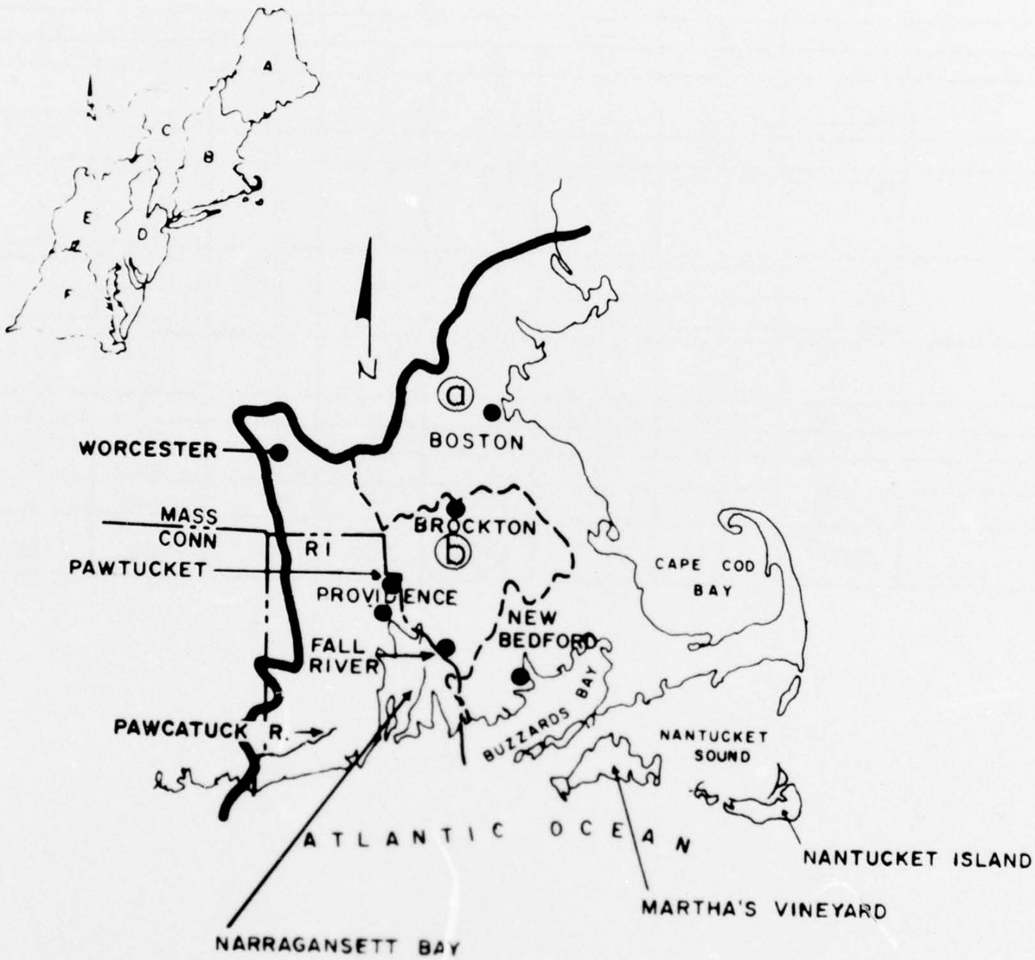
*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

AREA 8

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	1.6	1.2	0.4	0.8	0	0	1.6	1.2	0
	4.4	16.4	1.6	5.7	21.2	2.1	5.8	22.3	2.2
	4.0	4.5	5.7	3.6	4.6	6.6	4.0	5.7	7.1
	9	13	21	12	14	26	12	19	29
	0.85	1.51	2.20	0.85	1.70	2.77	0.90	1.94	3.22
	x	x	x	x	x	x	x	x	x
	6.17	4.44	1.61	3.04	0	0	6.17	4.44	0
	10.3	8.7	10.7	9.7	8.8	11.1	9.9	10.9	10.9
	0	91	263	0	0	0	0	15	61
	x	x	x	x	x	x	x	x	x
	0	0	0	8	14	14	8	14	14
				0.5	1.7	2.9			
	720	350	430	70	70	100	350	180	190
				3.1	2.7	3.3			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				410	580	1040			
				0	120	210			
				500	0	0			
	0.0	0.0	0.0	14.2	6.8	5.1	13.8	10.6	8.1
	0	0	0	160	0	0	160	0	0
	2.0	4.2	1.7	1.3	3.4	1.8	2.3	4.6	3.1
	49	37	52	15	22	32	49	36	52
	x	x	x	x	x	x	x	x	x
	405	99	99	197	44	44	Same	as	Eq
	2100	1300	2100	1400	900	1500	1900	1100	1700

AREA 9 SOUTHEASTERN NEW ENGLAND



AREA 9

Southeastern New England. Area 9 consists of all Atlantic coastal drainages of Massachusetts (except for the Merrimack River Basin) and Rhode Island. The Area has 4,576 square miles and is divided into two sub-areas. Sub-area a is all of the Massachusetts coastal drainages in the Area. Sub-area b is all of the Rhode Island coastal drainages which also drain a large portion of Massachusetts and a very small portion of Connecticut.

The Area has a unique shoreline and varies from coastal plain to rolling hills. Fine harbors and ports exist along the entire coastline that also has natural scientific interest. These ports include the large commercial ports of Boston and Providence and the very fine recreational harbors that abound along the Area's entire coast especially in Massachusetts, Cape Cod and Narragansett Bays. There are many resort and recreation sites including Cape Cod, Nantucket Island and Newport. A little over half of the Area is rural forest-town with medial visual quality. The rest of the Area is urban - including the Boston, Mass. and Providence, R. I. metropolitan regions. This Area has New England's highest population density.

The Area's very extensive, high quality, but fragile shorelines and natural scientific areas are significant attributes. Rural landscape covers about 60% of the Area and consists entirely of forest-town units of medial visual quality.

Total population was 4.9 million in 1960 with a projected increase to 8 million by 2020. The 1960 density was 974 people per square mile which is expected to increase to 1,833 people per square mile by 2020. The densest part of the Area is Suffolk County, Mass., with 14,207 people per square mile. Sub-area a has 1,222 people per square mile and b has 818 people per square mile.

Area 9 is the commercial, industrial, financial, educational and research center of New England. The 1960 employment of 1.7 million is expected to rise to 3.3 million by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and transportation, communication and public utilities. Employment is expected to decrease in agriculture, forestry and fisheries; food and kindred products; textile mill products; apparel and other textiles; lumber, wood products and furniture; petroleum and coal products; and wholesale and retail trade.

Per capita income was 9% above the 1960 national average, but is expected to decrease to 4% above by 2020.

Water is presently transferred into the Area from the Connecticut and Merrimack River Basins. These inter-basin transfers are expected to increase since there are no major water sources within the Area capable of meeting increasing future needs.

Water pollution in the Area is extensive and sharply limits the usefulness of all of the larger rivers and some portions of the coast. The largest water-using industries in Area 9 are chemicals and plastics, agricultural irrigation and paper. Chemicals and plastics are expected to still be the largest users in 2020, but paper will change to the second largest user followed by primary manufacturing.

Studies are presently being conducted in Area 9 including the Charles River Basin, Massachusetts; the Pawcatuck and Narragansett Bays Study; the Northeastern United States Water Supply Study (NEWS) which has assigned this Area a high priority; and the S. E. New England Comprehensive Study.

Area 9's average annual runoff is approximately 5,280 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,150 m.g.d., and the corresponding seven-day minimum is about 60% of this total, or 690 m.g.d. (See Appendix C). The addition of 110 m.g.d. as an allowance for the portion of the consumption losses reflected in the streamflow measurements, results in an existing firm resource available for use of about 800 m.g.d., or 15% of the average runoff. This does not include about 290 m.g.d., which can be imported into the Area by the Metropolitan District Commission.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,832 m.g.d., or 35% of the average runoff. Potential sources which would develop the increase of 1,032 m.g.d., include major storage, accounting for 8% of the increase; upstream storage, 20%, and ground water development, 72%.

Possible Alternative Planning Objectives. It is possible to emphasize any of the NAR planning objectives in Area 9 - alone or in combination. There are several characteristics of the Area, however, that should be considered when making a choice. First, Area 9 is one of the most densely populated of the NAR Areas, surpassed only by Area 13. It also includes some of the most extensive coastal resources in the Nation. This combination is a unique situation of extensive recreation and visual and cultural resources being very close to the people who are creating a large demand for their use. Second, sub-area a is highly industrialized, in addition to its large population, and has a great need for good water supplies. Third, sub-area b, while less densely populated and containing less industry, has income and employment problems. Fourth, Regional Development emphasis in sub-area a would be very expensive because of the lack of water in the sub-area for expansion of services. Fifth, Environmental Quality can be emphasized a great deal in Area 9. Such an emphasis would also be expensive but it could make a large change in the urban and rural environmental amenities.

Recommended Mixed Objective. Two sets of mixed objectives are recommended for Area 9 due to the significant differences between the income and employment levels of sub-areas a and b. It is recom-

mended that sub-area a primarily emphasize Environmental Quality with some attention given to National Efficiency. Sub-area a will be able to hold its economic position within the Region without outside aid, but there is a need to preserve its coastal and rural landscapes and improve its urban environment.

Sub-area b will need help in eliminating its unemployment. Its water resources managment program should be oriented towards increasing Regional Development, with some Environmental Quality to begin to retain the natural amenities of the sub-area.

Needs To Be Satisfied Water quality maintenance, publicly supplied and industrial self-supplied water and power plant cooling will be the most important needs in sub area a for gaining the mixed objective but will also be very difficult needs to meet. Publicly supplied and industrial self-supplied water withdrawal needs alone will be the most important to obtaining the mixed objective benefits in sub-area b.

Water pollution is a large problem in sub-area a because of its dense urbanization and high industrial development. Those needs which contribute most towards environmental quality, however, can only be fulfilled in sub-area a if high water quality is maintained. This key action would insure the usefulness of investments in the environmentally oriented needs: recreational boating, water recreation, fish and wildlife and visual and cultural. Water quality maintenance in sub-area b must achieve the state's standards but in a way that allows maximum industrial development combined with some environmental quality.

Large increases in population and industry in both sub-areas will be the cause of the large water withdrawal needs. Publicly supplied water needs will almost triple by 2020 and industrial self-supplied water needs will more than triple by 2020. Commercial navigation needs are large, grow rapidly and are fairly important to the industrial growth of both sub-areas especially during the later years of the planning period. While hydroelectric power generation will decrease during the planning period, reaching zero in 2000, the power plant cooling need will increase tremendously to match the industrial growth of the Area and the availability of coastal sea water. Each of the first two planning periods should realize more than a doubling of power requirements and a 50 percent increase between 2000 and 2020.

Agricultural irrigation needs are not of great importance to the Area but are large and will have a large increase in the first planning period as the industry increases its efficiency to remain competitive. This need will level off during the last two planning periods as growing urban areas prevent it from any expansion and as the change to irrigation is completed. Non-agricultural irrigation needs will grow slowly throughout

the period of the study, as golf courses expand to meet the population's recreation needs. The rural water supply need is comparatively small in Area 9 and it decreases during the third planning period as more rural inhabitants go onto publicly supplied water systems.

Water recreation and recreational boating needs are very large and important in Area 9. While the Area has some of the most extensive natural coastal waterways to fill these recreation needs, the facilities to insure proper use and preservation of these resources require a great deal of improvement. Even with the meeting of present water quality standards, which is central to obtaining maximum net benefits to this Area's mixed objective, the investment will be very large for water recreation and visual and cultural needs. The fulfillment of both of these latter needs will be important to the attainment of Environmental Quality benefits in sub-area a. Water recreation needs will grow rather steadily during the planning period. Visual and cultural needs, particularly quality landscape development, are very large and should grow most rapidly during the first stages of the planning period to insure protection of the remaining important landscape areas while they are available and to develop large areas of quality landscape. Urban amenities also need to be developed at this time to provide urban environmental quality.

Coastal shoreline and urban erosion needs are large and when fulfilled will return key benefits to the mixed objective of Area 9 from water recreation needs. Damages will be reduced on the coastal shorelines that are caused by hurricanes and storms and reduced in the urban areas that are caused by poor control of planning and new construction. Fulfillment of the large fish and wildlife and water recreation needs are also key to the visual and cultural needs. Commercial fishing will require special attention to retain its ability to contribute to the Area's income and cultural vitality. Meeting water quality maintenance needs and controlling land use around marshes and shorelines are especially important to fish and wildlife needs.

Flood damage reduction needs are large in this Area and they are expected to double during each of the last two planning periods as land becomes scarce during expansion of the Area's industry and population. Tidal flooding from hurricanes and from other coastal storms and flooding related to major urban drainage problems are particularly significant to the Area's development.

Fulfillment of health needs is important in Area 9 including the safeguarding of local shell fishing, extension of the control of mosquitoes and prevention of the spread of encephalitis. Drainage control needs are small and generally not important in this Area.

Devices. Water is an important component of many activities in this Area. Two types of devices are most important for fulfilling the Area's more significant needs: conveyance facilities and quality control facilities. The most important devices for

supplying the Area's water withdrawal needs will be conveyance facilities. These facilities will provide inter-basin diversions with some facilities for surface storage and ground water development. Publicly supplied water will be the largest of the needs to be met by these devices, primarily due to a future shift by much of the Area's industry from self-supplied to publicly supplied systems. Similarly, rural populations will continue to shift to central water systems.

The potential for surface water development will be very low in the Area, especially in sub-area a, unless high water quality standards are maintained to allow increased use of river water. Rhode Island, however, expects to be self-sufficient in water through 2020. Ground water is available in both sub-areas in consolidated rocks and glacial deposits but should be carefully developed to minimize quality problems and adverse effects on existing streamflows.

The second type of device includes almost all means of water quality control along with research for additional means of control. These devices will be necessary to meet water quality maintenance needs in sub-area a, as well as all withdrawal and many instream needs for the whole Area, such as recreation, fish and wildlife and visual and cultural. Water quality maintenance as well as irrigation water needs may be partially fulfilled in the future through the use of treated effluents. This device must be studied further.

Continued economic development in the Area, especially in sub-area a, also depends upon two other types of devices. The first are waterway management devices. Channel improvements will be important to meet commercial navigation needs and the same device along with recreational boating facilities will be needed for continued growth of recreational boating. The second set of devices will be those which satisfy power plant cooling needs. Only Saline water will be used in this Area but cooling towers and ponds and non-condensing power facilities will be needed. There may be a future shifting of power plants between the sub-areas depending upon how it is decided to best preserve the environmental quality associated needs of different parts of the Area -- especially the visual and cultural and fish and wildlife needs.

Investments in land control, land facilities and water access and in biological devices are fairly important in sub-area a for the visual and cultural and fish and wildlife needs which are large and difficult to meet. Fish and wildlife needs can not be completely met within the Area.

Devices of a somewhat lesser importance to achieving the mixed objective of this Area include most of those of a Water/Land nature. Shore erosion protection for selective portions of the ocean and river shorelines of the Area will be key to fulfillment of recreation needs. Watershed management activities, although fairly small, will be important in meeting flood damage reduction, drainage control

and visual and cultural needs of the Area. Local flood protection will be primarily for fulfilling hurricane and tidal flood damage reduction needs in the Area. Flood plain management will be able to fulfill the rest of the downstream flood damage reduction needs, especially in sub-area a, while some storage and watershed management devices will be required with flood plain management to fulfill the upstream needs.

The Area's important health needs will require insect control and water quality monitoring to aid, respectively, in the reduction of encephalitis and in the safeguarding of shell fishing.

Devices which change the levels of demand can be of great importance in this area for certain needs. Power plant cooling needs will be reduced and hydroelectric power needs will be met in this manner as non-condensing power facilities are used and reduce the need for cooling water. Recreation and fish and wildlife needs will similarly be met by the opening of existing public water supply reservoirs to public access and use. Such reservoir use changes, however, generally require new legislation and existing health laws require that such reservoir water be treated before it is used in public water systems. Pricing and rationing will also be useful in helping to meet fish and wildlife needs of the Area.

Other legal needs include: increased state regulation of well fields for safeguarding rural water supplies; strengthening of international commercial fishing pacts; better regulation of recreation craft; and interstate agreements for water diversions.

In view of the size of this Area's needs and of the central role that water plays in this Area's development, a Type II comprehensive water resources study should be carried out.

Benefits. Diversion of additional water into sub-area a will result in large benefits as it will allow publicly supplied water needs to be met. This action will also have multiple-use benefits since it will result in cost reduction for meeting industrial self-supplied water, irrigation water, water quality maintenance, water recreation and fish and wildlife needs.

Benefits from meeting water quality maintenance needs should also be high for sub-area a. Large multiple-use benefits from this need will accrue to publicly supplied water, fish and wildlife and visual and cultural needs. Any use of effluent irrigation methods will increase benefits even further due to the reuse of the water, and the inexpensive and useful disposal of the wastes.

Meeting commercial navigation needs will result in fairly large benefits to the Area. This need is an integral part of both sub-areas industrial activities and will help fill all the recreational boating needs and reduce the costs in providing recreational

boating facilities. The several navigation devices, along with public walking access to harbors will also produce multiple-use benefits to the visual and cultural needs.

Large benefits will accrue to the Area from the use of saline water for power plant cooling and from any future shifting of power plant locations from one part of the Area to another. These changes will increase the benefits for visual and cultural, fish and wildlife, water quality maintenance, publicly supplied water and industrial self-supplied water needs.

The benefits from investments in water recreation, visual and cultural, fish and wildlife, flood damage reduction and non-agricultural irrigation needs, while smaller than those just mentioned, will be fairly important to the Area and especially important to achievement of the Environmental Quality portion of the recommended mixed objective of sub-area a.

Devices that produce changes in demand for water recreation and fish and wildlife needs would provide especially large benefits with little investment. Pricing and rationing are the most likely devices to be used for this purpose.

Fulfillment of industrial self-supplied water needs will provide large and key benefits for the Regional Development objective of sub-area b that depends upon keeping basic resources readily available for any industrial growth. The enhancement of environment caused by fulfillment of shore erosion needs will be key to achievement of water recreation and visual and cultural needs and will increase the benefits that accrue to them.

There will also be benefits from meeting the needs of rural water supply, agricultural irrigation, drainage control, and health. These will be small benefits although watershed management will serve multiple uses aiding in the achievement of flood damage reduction, drainage control, erosion control, visual and cultural and water recreation needs. Fulfillment of urban erosion control needs will produce large benefits but benefits to coastal erosion control will be controversial. Coastal erosion control will be necessary to preserve much of this Area's shoreline but certain portions of the public will intensely fight its use to keep the shorelines natural.

Costs. Water quality maintenance costs, because of the quantity of wastes and the lack of treatment knowledge, are very high particularly in sub-area a where most of the efforts will be centered. Water recreation, erosion control, and visual and cultural costs will also be very high, especially during the earlier years of the planning period. The degree of urbanization and the size of the needs make these needs costly to meet in this Area. Recreation costs are highest in 1980 because of the inclusion of unsatisfied present demands. Visual and cultural needs are highest in 1980 because of the urgency of pre-

serving and developing unique landscapes and shorelines early in the program. There will be great difficulty in controlling coastal erosion and these costs will be the largest in the Region for meeting this need. Agriculture erosion costs are small but relatively important while urban erosion costs are fairly large.

Publicly supplied water and commercial navigation needs will be costly to meet. Initial capital investment costs for publicly supplied water needs will not be large in this Area. The costs will be proportionally larger than the needs they are fulfill in the first planning period, however, as allowances for project expansion are built into the projects and as the projects are built large enough to take full advantage of each site.

Additional costs will arise in this Area due to the interaction of some devices. High levels of nitrates found in some groundwater supplies and the maintenance of a minimum water table in the cranberry bogs will reduce the ability to use all available groundwater. Cranberry bog waters return to local streams with high levels of pesticides increasing water quality maintenance costs. Urban growth pressures will preclude the filling of some of the peak requirements for non-agricultural (golf course) irrigation needs. Some people in the Area will feel that shoreline erosion control, flood damage reduction and recreation projects will conflict with visual and cultural needs.

Alternative Programs. Emphasizing National Efficiency for all of Area 9 would significantly reduce the variety of devices used although water quality standards would still be met. The need and costs for publicly supplied water would stay high in the whole Area. This action would maintain the industry and population in sub-area a and encourage more industry in sub-area b. Diversions into the Area would still be necessary. Water recreation and visual and cultural needs would be greatly reduced in sub-area a. There would be no reduction in recreational boating needs because of the immense quantities of coastal resources available for such uses so close to several large population centers. Power plant cooling needs for saline water withdrawal would be raised slightly and their costs would be eliminated as most of the power plants would be put into sub-area a where the largest demand for power exists. Erosion and agricultural irrigation needs would be reduced as only the more efficient agricultural operations would continue to function. The large coastal erosion costs would be eliminated. Flood damage reduction needs would be fulfilled through increased use of hurricane barriers.

With a Regional Development emphasis in this Area changes would appear primarily in the program of sub-area a. Fewer water quality maintenance devices would be used including control of nutrients, storm water discharges and marine oil spills and separation of combined sewers. The costs would be reduced for power plant cooling as non-condensing facilities would not be used. Agricultural irrigation needs and costs would be raised for additional income to the Area. Water recreation needs for visitor days would rise slightly but the devices and costs used to meet these needs would be greatly lowered to increase the income to the Area through a lower quality of experience. Upstream flood damage reduction would be achieved through less use of flood plain management, especially in the last planning period; less use of watershed management and greater use of upstream reservoirs. More ocean projects would be used to meet the Area's tidal and hurricane flood damage reduction needs. Drainage control needs and costs would be increased, especially for forest, while erosion control needs and costs for streambanks and shorelines would be greatly reduced.

The emphasis upon Environmental Quality would be difficult to increase in this Area. The recommended levels of needs, devices and costs for this emphasis are already high for sub-area a, because of the present and expected levels of population and industrial growth in the region. Cropland drainage control and agriculture irrigation needs and costs can be increased only slightly because they are already large in the recommended program. Drainage control problems are especially large and intra-urban flood control projects would be used in the new and old urban communities. The levels of needs, devices and costs are also high in sub-area b because of the large emphasis in the present program to increase this sub-area's income and employment levels. Tourism can be increased slightly in this sub-area in a manner that, especially along the coast line, could help the local economy. The industry in the sub-area, however, should be encouraged rather than hurt when the water quality standards are enforced.

AREA 9

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	620	800	1130	1770
Industrial Self-Supplied Water (mgd)	180	290	510	690
Rural Water Supply (mgd)	9.2	9.9	15.0	10.0
Irrigation Water: agriculture (1000 afy)	12	33	34	34
non-agriculture (1000 afy)	10	26	43	65
Power Plant Cooling: withdrawal, saline (cfs)	5000	12000	29000	46000
brackish (cfs)				
fresh (cfs)				
consumption, brackish (cfs)				
fresh (cfs)				
Hydroelectric Power Generation (mw)	3	0	0	0
Navigation: commercial (m. tons annually)	43	56	94	159
recreational boating (1000 boats)	190	250	560	910
Water Recreation: visitor days (m.)	x	92	146	212
stream or river (miles)	x	630	820	1170
water surface (1000 acres)	x	230	340	470
beach (acres)	x	1600	2000	2400
pool (m. sq. ft.)	x	27	35	41
land facilities (1000 acres)	x	120	160	200
Fish & Wildlife: sport fishing man-days (m.)	10	12	15	18
surface area, lake (acres)	x	2000	8500	25000
stream (acres)	x	800	2100	3600
access, fresh (acres)	x	110	280	470
salt (acres)	x	860	2310	3990
anadromous (acres)	x	6	8	10
piers (1000 feet)	x	24	65	113
hunting man-days (m.)	1.5	1.7	2.0	2.4
access (1000 sq. mi.)	x	0.5	1.0	1.2
nature study man-days (m.)	5.9	6.9	8.6	10.5
access (1000 acres)	x	11	28	49
Water Quality Maint.: non-industrial (m. PEs)	4.3	5.3	6.5	8.1
industrial (m. PEs)	3.4	5.7	9.7	16.7
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	6	9	17	34
mainstream (m.$)	3	5	9	18
tidal & hurricane (m.$)	7	11	20	41
Drainage Control: cropland (1000 acres)	6	8	13	14
forest land (1000 acres)	x	0	1	3
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	54	70	78	80
urban (1000 acres)	530	680	920	1280
stream bank (mi.)	x	5	14	23
coastal shoreline (mi.)	x	540	1090	1120
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	50	850	850	850
unique shoreline (mi.)	x	20	20	20
high quality (sq.mi.)				
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	200	400	600
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	50	50	50

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	760	1010	1410	800	1120	1700	800	1130	1770
	280	450	570	280	480	630	290	510	690
				9.9	15.0	10.0			
	36	38	38	31	21	21	36	38	32
	27	44	65	26	43	65	26	43	65
	12000	29000	44000	12000	31000	50000	12000	28000	47000
				5	0	0			
	49	64	83	53	83	132	56	94	159
				250	560	910			
	92	146	212	80	127	199	94	150	212
	630	820	1170	210	270	390	310	400	580
	230	340	470	62	93	130	120	180	250
	1600	2000	2400	600	800	1000	700	900	1000
	27	35	41	11	15	19	14	18	20
	120	160	200	20	30	40	40	60	70
				12	15	18			
				2000	8500	25000			
				800	2100	3600			
				110	280	470			
				860	2310	3990			
				6	8	10			
				24	65	113			
				1.7	2.0	2.4			
				0.5	1.0	1.2			
				6.9	8.6	10.5			
				11	28	49			
				5.3	6.5	8.1			
				5.7	9.7	16.7			
				9	17	34			
				5	9	18			
				11	20	41			
	9	15	16	8	13	14	9	15	16
	0	1	3	0	1	3	1	3	7
	70	78	80	64	70	71	70	78	80
	680	920	1280	590	770	1050	680	920	1280
	5	14	23	1	3	5	2	7	12
	540	1090	1120	3	11	19	8	23	38
	x	x	x	x	x	x	x	x	x
	850	850	850	850	850	850	Same	as	EQ
	20	20	20	10	10	10	Same	as	EQ
	200	400	600	100	200	300	Same	as	EQ
	50	50	50	0	50	50	Same	as	EQ

AREA 9

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	156*	x*	x*
mainstream (1000 af)	FW,Rec,VC,WQ	26*	x*	x*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Irrig	240	530	680
brackish (mgd)	Ind	70	120	160
estuarine (mgd)				
ocean (mgd)	Pow	x	x	x
wells (mgd)		29 *	10 *	9*
Conveyance Facilities				
interbasin diversions, into (mgd)		120*	490*	740*
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	74	120	520
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC	9.4	0	0
secondary (90%) (m. PE removed)	WQ	0	15	22
advanced (95%) (m. PE removed)	WQ	0	0.81	1.24
effluent irrigation	Irrig	x	x	x
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x	x	x
Pumped Storage				
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	31	19	84
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)	FDR	0	3	0
river (projects)	FDR	7.5	9.5	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	180	310	190
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig

⧣ Also includes the following purposes: FW,VC,Rec

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig ≠	17	1	x	Irrig ≠	13	x	x	Irrig ≠	17	1	x
PS,WQ ≠	145	33	59	PS,WQ ≠	179	43	202	PS,WQ ≠	185	44	219
**	200	370	330	**	230	500	590	**	240	530	680
Ind	70	90	110	Ind	70	100	140	Ind	70	120	170
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	87	128	19	Rur**	93	125	20	Rur**	98	121	20
PS	63	112	130	PS	80	150	300	PS	80	150	360
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
PS	58	89	227	PS	72	117	450	PS	74	120	520
				WQ,VC	9.4	0	0				
				WQ	0	15	22				
				WQ	0	0.81	1.24				
WQ,VC	x	x	x								
WQ,VC	x	x	x								
WQ,VC	x	x	x								
WQ,VC	x	x	x								
FDR,VC	34	21	124	FDR,VC	28	15	43	FDR,VC	27	16	43
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	0	1	0	FDR	0	4	0	FDR	0	4	0
FDR	1.0	0	0	FDR	13.0	20.0	0	FDR	14.0	19.0	0
FDR,Drn,VC	190	390	390	FDR,Drn,VC	160	230	x	FDR,Drn,VC	170	220	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x	x	Nav	x	x	x
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 9

DEVICES–incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying) (sq.mi.)	VC, FW	450	200	200
fee simple purchase (buying) (mi.)	VC, FW	20	0	0
purchase lease (sq.mi.)	VC,FW	0	0	0
easements (sq.mi.)				
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)	VC, FW	600	0	0
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs. (sq.mi.)				
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec, Hlth	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing	FW	x	x	x
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions	Rec,FW	x	x	
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	17	44	0
Ground Water Recharge	Ind	x	x	x
Use of Waste Thermal Heat	Pow	x	x	x
Oil Spill Control	FW,VC,WQ	x	x	x
Flood Skimming	Ind	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	450	200	200	VC, FW	100	0	0	Same	as	EQ	
VC, FW	20	0	0	VC, FW	10	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	100	150	100	"	"	"	
VC, FW	600	0	0	VC, FW	700	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
				WQ		x					
Pow		x	x								
FW	x	x	x	FW	x	x	x	FW	x	x	x
Rec, FW	x	x	x	Rec,FW	x	x	x	Rec,FW	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FDR	30	41	0	FDR	33	88	0

AREA 9

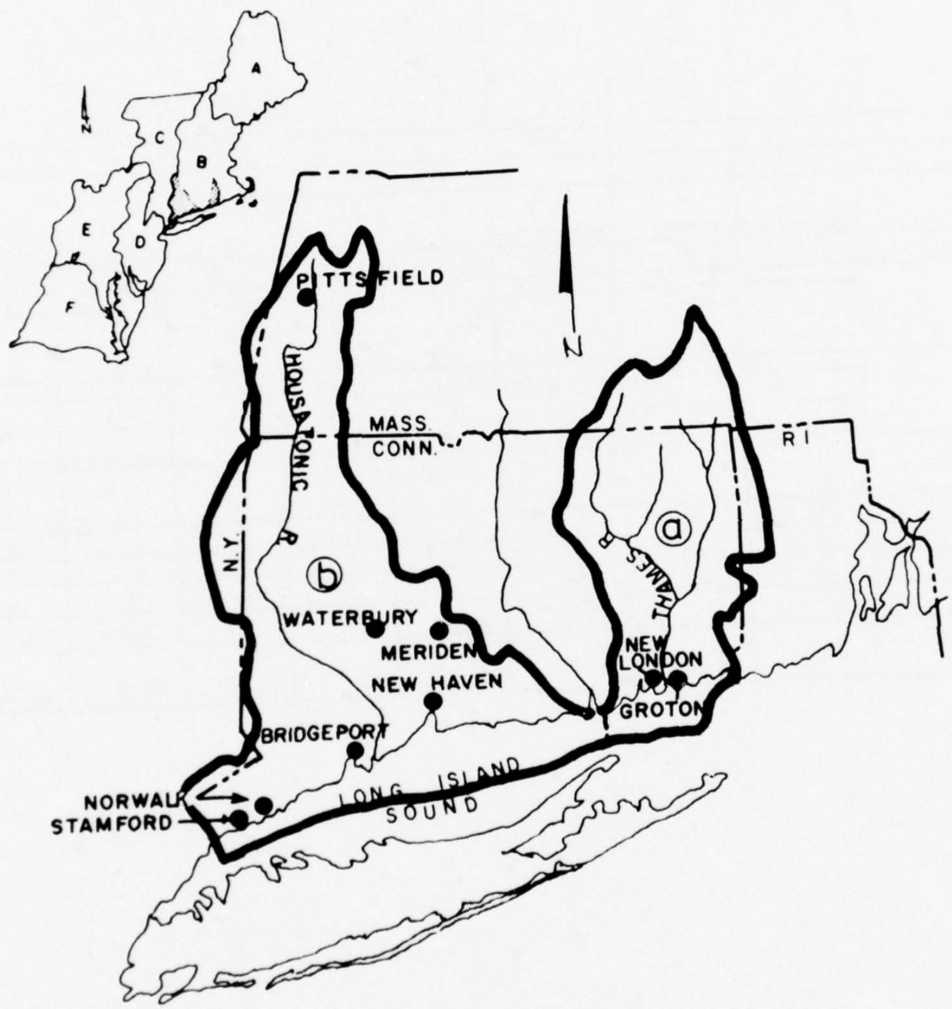
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	46.7*	0*	0*	
mainstream	9.7*	0*	0*	
wells	12.8*	4.4*	3.9*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	0.4*	170.7*	57.9*	
public water supply	15	28	95	
industrial self-supplied water	0.82	1.74	1.84	
rural water supply	x	x	x	
irrigation, agriculture	2.04	0.16	0	
nonagriculture	14	14	18	
Power Plant Cooling Water	0	30	130	
Hydroelectric Power Generation				
Navigation: commercial	20	135	89	
recreation	4.2	12.5	14.5	
Water Recreation	970	630	670	
Fish and Wildlife: fishing	4.7	7.5	8.7	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	340	780	1180	
advanced	0	170	250	
other ≠	1550	0	0	
Flood Damage Reduction: upstream	3.7	6.6	0	
mainstream	32	27	0	
Drainage Control	0.18	0.49	0.18	
Erosion Control	973	1013	113	
Health	x	x	x	
Visual and Cultural	439	70	70	
Summation of Available Estimated Costs	4400	3100	2700	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.6	0.1	0	0.4	0	0	0.6	0.1	0
	33	19	21	41	25	52	42	25	56
	5.8	7.2	3.7	5.8	7.0	3.9	6.1	6.9	3.8
	26.5	45.0	19.3	32.8	59.0	46.0	34.2	60.0	55.0
	14	24	49	15	28	84	15	28	95
	0.78	1.16	1.26	0.78	1.50	1.58	0.82	1.74	1.84
	x	x	x	x	x	x	x	x	x
	2.55	0.32	0	1.52	0	0	2.55	0.32	0
	14	13	17	14	14	18	14	14	18
	0	57	187	0	0	0	0	18	18
	0	0	0	20	135	89	20	135	89
	←			4.2	12.5	14.5			→
	970	630	670	140	100	150	240	120	240
	←			4.7	7.5	8.7			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			340	780	1180			→
	←			0	170	250			→
	←			1550	0	0			→
	0	0	0	8.0	13.3	0	7.4	13.1	0
	32	7	0	32	30	0	32	30	0
	0.27	0.58	0.18	0.18	0.49	0.18	0.31	0.62	0.27
	973	1013	113	15	44	59	39	65	85
	x	x	x	x	x	x	x	x	x
	439	70	70	208	53	35	Same	as	EQ
	4400	2900	2600	2400	1500	2000	2800	1600	2200

AREA 10 THAMES AND HOUSATONIC RIVER BASINS



AREA 10

Housatonic and Thames River Basins. Area 10 covers 4,555 square miles and is divided into two sub-areas physically separated by Area 8. Sub-area a is comprised of the Thames River basin and the Connecticut coastal drainage east of the Connecticut River basin. This sub-area is in Connecticut and Massachusetts with a small portion in Rhode Island. Sub-area b is made up of the Housatonic River basin and Connecticut's coastal drainage west of the Connecticut River basin. This sub-area is in Connecticut with small portions in Massachusetts and New York.

Eighty percent of the Area is comprised of rolling hills and twenty percent is steep hills. The predominant land-use pattern is forest-town with lesser amounts of city and town-farm units. Overall landscape quality for the Area is of medial to high quality.

Early settlement was limited to villages in the valleys of the primary navigable rivers. The infertile soil caused some of the colonists to change from subsistance agriculture to fishing, lumbering, shipbuilding and fur trading. By 1800, the coastal regions were fairly densely populated and today are a part of the dense metropolitan system of settlement along the eastern seaboard between New York City and Boston.

The 1960 population of the Area was 1,898,946 with the greatest concentration in New Haven County where the density was 1,092 per square mile. The population density of the whole Area was 417 people per square mile. The population of sub-area a was approximately 323,100 with 189 people per square mile and sub-area b had approximately 1,575,900 people with 554 per square mile. The projected population for 2020 is 4.1 million.

Per capita income in 1960 was 21% above the national average but is projected to decline to only 5% above by 2020.

The 1960 employment of 757,000 is projected to increase to 1,555,000 by 2020. Sub-area b has 80 percent of the Area's employment. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and contract construction. Employment is expected to decrease in agriculture, forestry and fisheries; mining; food and kindred products; textile mill products; apparel; petroleum and coal products; and primary metals.

Water is generally abundant in both sub-areas. Municiipal and industrial pollution, however, has degraded the quality of the water adjacent to the population centers, particularly in sub-area b.

Average annual runoff in Area 10 is approximately 4,870 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 520 m.g.d., and the corresponding seven-day minimum is about 60% of this total, or 312 m.g.d. (See Appendix C). The addition of 82 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 394 m.g.d., or 8% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,373 m.g.d., or 28% of the average runoff. Potential sources which would develop the increase of 979 m.g.d., include major storage, accounting for 55% of the increase; upstream storage, 22%, and ground water development, 23%.

Possible Alternative Planning Objectives. The large differences between the sub-areas of Area 10 -- their physical sizes and population levels and densities - seem to point towards the use of different objective mixes for each. In addition, the Area's above average per capita income seems to prevent placing the primary emphasis of the objective mix upon Regional Development. Apart from these conditions, Area 10 can support any other mix of N.A.R. planning objectives.

Recommended Mixed Objective. National Efficiency and Regional Development should receive equal emphasis in sub-area a with some attention given to Environmental Quality. The sub-area's high level of income leads to the National Efficiency emphasis but there are enclaves of underdevelopment that require the equal attention of Regional Development. Environmental Quality is necessary to prevent degradation of the sub-area's resources from projected high recreational use.

Sub-area b should equally emphasize Environmental Quality and Regional Development. There are presently heavy recreational pressures on the sub-area's resources that require special attention to ensure a high quality environment. There are also enclaves of low income and unemployment in this sub-area that should be the target of economic aid.

Needs To Be Satisfied. The most immediate of the Area's needs are for water recreation, hydroelectric power generation, publicly supplied water and tidal and hurricane flood damage reduction. Population projections for Area 10 indicate a higher than average growth rate along with a fairly high industrial growth rate. To sustain this anticipated expansion there will have to be maintenance of water quality standards and relatively high visual and cultural needs especially the development of metropolitan amenities and quality landscape. Industrial self-supplied water needs will be fairly small on a percapita basis and it is expected that in the latter part of the planning period the additional water needed to meet industrial growth will have to be publicly supplied. Satisfaction of the rapidly growing commercial navigation, recreational boating, flood damage reduction and fish and wildlife needs will also be required. Rural water needs will be fairly large in the

first two periods although it will have a decreasing growth rate during the last period as rural systems are replaced by publicly supplied systems.

Non-agricultural irrigation needs will have moderate growth rates throughout the planning period whereas agricultural irrigation water needs will follow a declining trend. Power plant cooling withdrawal needs will be large for saline water in all time periods and moderate for fresh and brackish water in 2020. Future power generation will continue to move to coastal sites. Hydroelectric power generation needs will greatly increase in each time frame as use is made of the many excellent sites available for pumped storage facilities. Fish and wildlife needs grow very rapidly throughout the planning period. The shell fisheries for clams and oysters should receive special consideration in this Area.

Drainage control, health and erosion control needs, with the exception of urban erosion control, will be low throughout the period of study. Nevertheless, the fulfillment of these needs will be fundamental to the achievement of Environmental Quality and National Income benefits. Drainage control needs will consist mainly of cropland areas and health needs are vector and pollution control.

Devices. The most important types of devices for satisfying the more significant needs are storage and water quality control facilities. Corresponding water handling devices will be required including use of all withdrawal facilities. These devices will provide for the needs of publicly supplied, industrial self-supplied, rural and irrigation water and aid in fulfilling the needs of flood damage reduction, water quality maintenance, water recreation, visual and cultural and power plant cooling.

Continued economic development, especially in the lower reaches of the two sub-areas, depends upon a variety of devices. For navigation needs, the devices include channel improvements and recreational boating facilities in all time periods.

Flood plain management and river projects will be required for all types of flood damage reduction needs; but reservoirs and watershed management will only be used in upstream areas and ocean projects used only in tidal and hurricane areas. Power plant cooling will rely heavily on ocean intakes in all time periods and on cooling towers and non-condensing base load facilities in the mid and later time periods. These various devices will help meet the needs of recreational boating, water recreation, visual and cultural, and fish and wildlife. Hydroelectric power generation needs will be fulfilled by pumped storage devices and will require careful siting to prevent damage to the environment.

Devices of moderate importance to the mixed objectives are fee simple purchase, purchase leases, and easement rights which will accomodate fish and wildlife and visual and cultural needs in all time periods but

will place some emphasis on the early time frame. Habitat management, stocking and fishways will be used to aid fish and wildlife needs.

Policy changes will be moderately important in Area 10 and include changes in project design loads for recreation needs and the removal of some existing projects for fish and wildlife needs.

Benefits. Satisfying water quality maintenance needs will provide large benefits to water recreation, publicly supplied and industrial self-supplied water, and fish and wildlife needs. Almost all types of quality control facilities will be used to achieve this water quality maintenance. Erosion protection measures that result in reduced sediment load will produce small benefits by helping fulfill the water quality maintenance need. Moderate benefits will be produced for erosion needs by coastal shoreline devices.

Storage for multipurpose use will result in large benefits. This storage will provide benefits for all water withdrawal related and water quality maintenance needs in addition to providing visual and cultural benefits by maintaining landscape diversity in this Area's rolling and hilly topography. Moderate benefits to water recreation, fish and wildlife and flood damage reduction needs will also accrue from storage.

Channel improvements and other navigation devices should result in high benefits by fulfilling the commercial and recreational boating needs of the many port cities in this Area. Less extensive benefits will be derived from fulfilling the needs of health, flood damage reduction and power plant cooling.

Costs. Costs for fulfilling water recreation needs are very high, particularly in 1980. This is because of the facilities that must be provided for the large existing and future needs while maintaining high environmental quality standards. Water quality maintenance costs are high in order to provide the degree of treatment necessary for fulfillment of the Area's environmentally related needs. Visual and cultural costs are high in 1980 because of the importance of early implementation of devices to develop or preserve unique shoreline high quality landscape landscape diversity and metropolitan amenities. Power plant cooling becomes relatively expensive in 2020 due to the increased need for cooling towers and non-condensing facilities. to meet the objective mix. The large amount of storage and water treatment plant capacity required in target year 2000 combine to make costs of publicly supplied water fairly high for this time period.

Overall, costly interactions between devices range between low and moderate, and there will be little reduction in benefits to any particular need caused by fulfilling the other needs in Area 10.

Alternative Programs. If Environmental Quality were chosen to be emphasized throughout the Area, the needs for commercial navigation and publicly supplied and industrial self-supplied water would be lower; the needs for irrigation water, cropland drainage control and visual

and cultural would be larger while those of visual and cultural and flood damage reduction would use different devices and commercial navigation would use no devices. The irrigation and drainage of cropland to maintain landscape diversity would be stimulated by increased investment. Power plant cooling needs would be reduced as increased use would be made of non-condenser facilities. Much less fresh water would be withdrawn and consumed and less saline water would be withdrawn during the last two time periods. Increased use would be made of brackish water. Visual and cultural needs would increase for maintenance of unique natural and diverse landscapes and for development of quality landscape. Devices for visual and cultural needs would be shifted from purchase lease to fee simple purchase. Structures would be de-emphasized for upstream flood damage reduction with increased use of flood plain and watershed management which would reduce expenditures. Commercial navigation needs would be met with no use of channel improvements at greatly reduced costs. Diversion of cargo would be employed so that navigation needs would require fewer facilities.

If National Income were chosen the needs of power plant cooling, would be larger while those of recreation, erosion control, publicly supplied and industrial self-supplied water would be lower. Power plant cooling needs would be increased in the last time frame as non-condenser devices would not be used. Less saline water would be used in the last time period while during the last two periods there would be increased withdrawal and consumption of brackish water and increased withdrawal but decreased consumption of fresh water. This would result in greater power generation for less investment. Upstream flood damage reduction needs would be satisfied by less flood plain and watershed management and more reservoirs. The reduced water recreation needs would be met with greatly reduced use of all devices which would greatly reduce the cost. Erosion would be controlled only where it would be economically beneficial. Publicly supplied and industrial self-supplied needs would be smaller and the water quality devices for protecting the environment would be de-emphasized including nutrient control, storm water discharge control, septic tank control and separation of combined sewers. Some visual and cultural needs would decrease, including: maintenance of landscape diversity and development of quality landscape. Additional purchase leases would be used with fewer fee simple purchases to gain these needs.

If Regional Development were chosen to be emphasized in Area 10, the needs of agriculture irrigation water, commercial navigation, drainage control and visual and cultural would be larger. Those needs of power plant cooling, water wuality maintenance, water recreation, and flood damage reduction would use different devices. The needs for streambank erosion control would be smaller and greatly reduced for shoreline erosion control. Power plant cooling needs would be increased in the last planning period as no use would be made of non-condenser facilities. Less saline water would be withdrawn to reduce costs but there would be increased use of estuarine intakes, brackish withdrawal and brackish and fresh water consumption. Total fresh water withdrawal would be decreased. Water recreation would be developed for high density use which would reduce expenditures considerably. Upstream flood damage reduction by reservoirs would be emphasized at an additional investment rather than flood plain and watershed management. Water quality maintenance needs would not use control of stormwater discharges, nutrients, and septic tanks nor separation of combined sewers. The needs for visual and cultural would increase for maintenance of diverse landscapes and for development of quality landscapes. Devices would be shifted from purchase lease to fee simple purchase.

AREA 10

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	260	350	540	770
Industrial Self-Supplied Water (mgd)	100	170	300	510
Rural Water Supply (mgd)	21	29	61	28
Irrigation Water: agriculture (1000 afy)	2.8	8.4	4.3	2.2
non-agriculture (1000 afy)	6	17	29	45
Power Plant Cooling: withdrawal, saline (cfs)	2000	6000	13000	19000
brackish (cfs)	0	0	0	500
fresh (cfs)	0	0	82	183
consumption, brackish (cfs)	0	0	0	5
fresh (cfs)	0	0	43	95
Hydroelectric Power Generation (mw)	100	800	3000	9000
Navigation: commercial (m.tons annually)	20	28	47	84
recreational boating (1000 boats)	130	170	310	670
Water Recreation: visitor days (m.)	x	91	150	225
stream or river (miles)	x	490	670	920
water surface (1000 acres)	x	160	260	350
beach (acres)	x	1200	1700	2100
pool (m. sq. ft.)	x	22	29	36
land facilities (1000 acres)	x	90	130	170
Fish & Wildlife: sport fishing man-days (m.)	3.6	4.3	5.6	7.0
surface area, lake (acres)	x	700	2400	7600
stream (acres)	x	1500	5200	7000
access, fresh (acres)	x	40	140	260
salt (acres)	x	200	600	1200
anadromous (acres)	x	3	4	5
piers (1000 feet)	x	5	18	32
hunting man-days (m.)	0.76	0.79	1.02	1.28
access (1000 sq. mi.)	x	0.2	0.8	1.3
nature study man-days (m.)	2.7	3.1	4.0	5.1
access (1000 acres)	x	0.2	0.8	1.3
Water Quality Maint.: non-industrial (m. PEs)	1.9	2.6	3.4	4.1
industrial (m. PEs)	0.3	0.5	0.9	1.7
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	4	7	13	27
mainstream (m.$)	3	5	10	20
tidal & hurricane (m.$)	8	12	24	49
Drainage Control: cropland (1000 acres)	19	25	40	46
forest land (1000 acres)	x	0	1	3
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	100	130	150	160
urban (1000 acres)	270	480	660	910
stream bank (mi.)	x	5	15	25
coastal shoreline (mi.)	x	72	146	151
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)				
unique shoreline (mi.)	x	80	80	80
high quality (sq.mi.)				
diversity (sq.mi.)	x	20	40	60
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	230	460	690
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	45	55	55

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	340	480	640	350	530	760	350	540	770
	160	270	410	160	280	460	170	300	510
				28	61	28			
	13.5	21.4	24.4	8.4	4.3	2.2	13.5	21.4	19.3
	19	31	45	17	29	45	18	30	45
	6000	9000	9000	6000	10000	8000	6000	9000	8000
	0	2000	5000	0	1000	5900	0	3000	6700
	0	0	20	0	2300	3900	0	30	170
	0	16	43	0	8	46	0	25	49
	0	0	10	0	20	38	0	13	73
				800	3000	9000			
	25	38	57	28	47	84	29	53	99
				170	310	670			
	91	150	225	80	131	208	93	154	221
	490	670	920	160	220	300	240	330	450
	160	260	350	40	70	100	90	130	180
	1200	1700	2100	500	600	900	600	800	900
	22	29	36	9	12	17	11	15	18
	90	130	170	20	20	30	30	40	60
				4.3	5.6	7.0			
				700	2400	7600			
				1500	5200	7000			
				40	140	260			
				200	600	1200			
				3	4	5			
				5	18	32			
				0.79	1.02	1.28			
				0.2	0.8	1.3			
				3.1	4.0	5.1			
				0.2	0.8	1.3			
				2.6	3.4	4.1			
				0.5	0.9	1.7			
				7	13	27			
				5	10	20			
				12	24	49			
	28	47	53	25	40	46	28	47	53
	0	1	3	0	1	3	1	3	9
	130	150	160	120	130	130	130	150	160
	480	660	910	340	460	650	480	660	910
	5	15	25	1	3	5	2	7	12
	72	146	151	0	1	2	1	3	5
	x	x	x	x	x	x	x	x	x
	80	80	80	80	80	80	Same	as	EQ
	30	60	90	15	30	45	Same	as	EQ
	300	600	900	150	300	450	Same	as	EQ
	55	55	55	30	55	55	Same	as	EQ

AREA 10

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	26*	8*	178*
mainstream (1000 af)	FW,Rec,VC,WQ	26*	140*	260*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	49	97	180
brackish (mgd)	Ind	190	260	130
estuarine (mgd)	Pow			x
ocean (mgd)	Pow	x	x	x
wells (mgd)		18*	20*	134*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow		x	x
chemical/biological				
potable water treat plants (mgd)	PS	7	345	31
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC	2.6	0	0
secondary (90%) (m. PE removed)	WQ	0	3.9	5.2
advanced (95%) (m. PE removed)	WQ	0	0.22	0.29
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG	x	x	x
Desalting Facilities		0*	0*	0.4*
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	9	14	12
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)	FDR	2	0	0
river (projects)	FDR	10	7	3
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	270	300	240
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig
ǂ Also includes the following purposes: VC,Rec

	ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
	Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
	Irrig ≁	8	6.0	2.0	Irrig ≁	4	x	x	Irrig ≁	8	6	x
	PS,WQ ≁	46	212	x	PS,WQ ≁	53	263	x	PS,WQ ≁	55	267	x
	Pow**	46	74	123	Pow**	46	85	157	**	49	97	180
	Ind	180	200	40	Ind	180	240	80	Ind	190	260	130
	Pow		x	x	Pow		x	x	Pow		x	x
	Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
	Rur**	57	102	60	Rur**	56	113	77	Rur**	58	119	80
	Pow			x	Pow			x	Pow		x	x
	PS	6	282	21	PS	7	338	31	PS	7	345	31
					WQ,VC	2.6	0	0				
					WQ	0	3.9	5.2				
					WQ	0	0.22	0.29				
	WQ,VC	x	x	x								
	WQ,VC	x	x	x								
	WQ,VC	x	x	x								
					HPG	x	x	x				
	FDR,VC	14	24	16	FDR,VC	7	x	8	FDR,VC	4	3	7
	FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
	FDR	2	0	0	FDR	2	0	0	FDR	2	0	0
	FDR	2	1	0	FDR	7	23	0	FDR	18	12	6
	FDR,Drn,VC	240	490	490	FDR,Drn,VC	160	250	x	FDR,Drn,VC	300	110	x
	Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
	Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
	Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
	Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
					Nav	x	x	x	Nav	x	x	x
	Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 10

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	190	190	190
fee simple purchase (buying) (mi.)	VC, FW	15	0	0
purchase lease (sq.mi.)	VC, FW	90	55	45
easements (sq.mi.)	VC, FW	15	15	15
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)	VC,FW	65	0	0
zoning and/or tax inc. subs.(sq.mi.)				
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow			x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	35	17	4
Protect Shellfish	Hlth	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	370	320	320	VC,FW	0	0	0	Same	as	EQ	
VC, FW	20	0	0	VC, FW	10	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	180	175	175	"	"	"	
VC, FW	15	15	15	VC, FW	15	15	15	"	"	"	
VC, FW	60	0	0	VC, FW	70	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x		WQ		x		WQ		x	
Pow		x	x								
				FW	x	x	x				
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	40	63	0	FDR	69	34	7

AREA 10

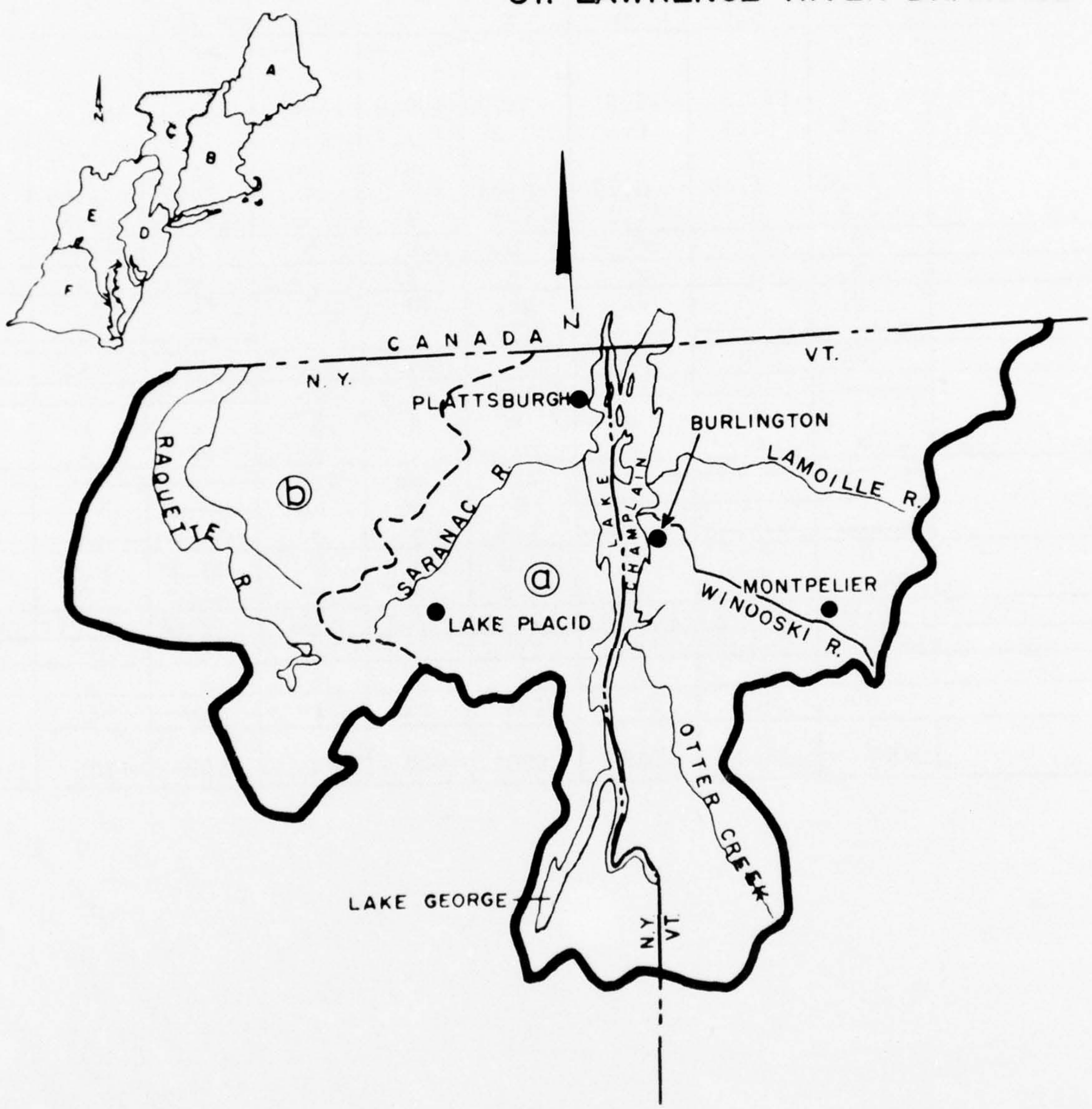
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	10.8*	7.2*	67.6*	
mainstream	12*	28*	85*	
wells	9.9*	10.7*	11.2*	
desalting	0*	0*	0.8*	
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	5.4	161.9	16.4	
industrial self-supplied water	1.3	1.9	1.6	
rural water supply	x	x	x	
irrigation, agriculture	0.75	0	0	
nonagriculture	9.9	9.1	12.0	
Power Plant Cooling Water	0	24	55	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial	58	50	115	
recreation	1.3	9.3	12.7	
Water Recreation	920	550	430	
Fish and Wildlife: fishing	1.3	2.9	3.5	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	220	310	420	
advanced	0	44	60	
other †	250	0	0	
Flood Damage Reduction: upstream	15.6	4.2	0.8	
mainstream	46.2	7.7	0	
Drainage Control	0.53	1.37	0.62	
Erosion Control	151	145	48	
Health	x	x	x	
Visual and Cultural	298	78	75	
Summation of Available Estimated Costs	2000	1400	1400	

*From the supply model and includes OMR costs.

† Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.5	0.5	0.2	0.2	0	0	0.5	0.5	0
	12	59	0	13	74	0	14	75	0
	4.0	4.7	4.6	3.8	5.1	5.4	4.1	5.5	5.5
	0	0	0	0	0	0	0	0	0
	4.6	133.3	11.9	5.2	159.0	16.4	5.4	161.9	16.4
	1.2	1.5	0.8	1.2	1.7	1.3	1.3	1.9	1.6
	x	x	x	x	x	x	x	x	x
	1.92	1.69	0.69	0.75	0	0	1.92	1.69	0
	10.5	8.9	11.6	9.9	9.1	12.0	10.1	9.2	11.8
	0	52	194	0	0	0	0	10	35
	x	x	x	x	x	x	x	x	x
	0	0	0	58	50	115	58	50	115
				1.3	9.3	12.7			
	920	550	430	50	150	240	200	250	250
				1.3	2.9	3.5			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				220	310	420			
				0	44	60			
				250	0	0			
	0	0	0	11.0	28.0	0	31.2	8.5	1.5
	46.2	7.7	0	46.2	7.7	0	46.2	7.7	0
	0.80	1.73	0.62	0.53	1.37	0.62	0.84	1.77	0.80
	151	145	48	14	21	32	38	31	44
	x	x	x	x	x	x	x	x	x
	395	98	98	198	56	49	Same	as	EQ
	2000	1400	1300	900	900	1000	1300	1100	1100

AREA II LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE



Area 11

Lake Champlain and the St. Lawrence River Drainage. Area 11 covers 11,900 square miles and includes portions of the States of New York and Vermont. This Area is divided into two sub-areas. Sub-area a consists of the United States portion of the Lake Champlain drainage plus several streams that are located between this drainage and the Connecticut River basin. Sub-area b includes all of those streams west of the Lake Champlain drainage that flow into the St. Lawrence River before it crosses the United States - Canadian boundary.

Lakes and ponds are numerous in the Area. Sub-area a consists of lowlands around Lake Champlain sloping up to rolling country with terraces and delta plains, and rising to mountainous terrain in the headwaters. Sub-area b is characterized by hills and ridges upstream, and relatively flat land approaching the main valley floor.

This Area has high quality and diverse landscape. There are two distinct and unusual mountain ranges, the Adirondacks and the Green Mountains. The open farm landscape of the Champlain Valley provides visual access to the mountains and to the large expanse of Lake Champlain itself. The cultural land-use pattern is highly diversified throughout Area 11. About one-third of the Area is in forest-wildland and the rest somewhat equally divided into town-farm, farm, farm-forest, and forest-town. One-third of the Area is of high visual quality, 10% is medial, and 20% is low. The open farm landscape of the Champlain Valley provides visual access to both the Adirondack and Green Mountains, and to Lake Champlain.

The Area's 1960 population was 511,654 with a density of 43 people per square mile which is the same in each sub-area. Sub-area a had approximately 358,600 people and sub-area b had approximately 156,000 people. The population is projected to increase to 792,600 by the year 2020, an increase of 55%.

Per capita income was 19% below the national average in 1959, but is expected to increase to 9% below by 2020.

Total employment was 171,108 in 1960 and is projected to increase to 317,200 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; agriculture, forestry and fisheries; and contract construction. Employment is expected to decrease in agriculture, forestry and fisheries; textile mill products; apparel and other textiles; lumber, wood products and furniture; petroleum and cool products; primary metals; and fabricated metals and ordinance. Food, primary metals, agriculture and mining were the major water-using industries in 1960.

The Area has sufficient water to meet present and future water withdrawal needs. Certain demand centers in the northwest portion,

however, have been and will continue to be most economically satisfied by direct withdrawals from the St. Lawrence River just outside the NAR. Several local areas of pollution occur along the Area's streams due to municipal and industrial discharges.

Average annual runoff in Area 11 is approximately 12,145 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,700 m.g.d., and the corresponding seven-day minimum is about 60% of this total, or 1,610 m.g.d. (See Appendix C). The addition of 30 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 1,640 m.g.d., or 13% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 3,473 m.g.d., or 29% of the average runoff. Potential sources which would develop the increase of 1,833 m.g.d., include major storage, accounting for 49% of the increase; upstream storage, 19%, and ground water development, 32%.

Possible Alternative Planning Objectives. This Area's low level of per capita income indicates a need for economic development programs which would limit the degree to which National Efficiency could be emphasized. The Area also has a great deal of environmental high quality and diverse landscape which is one of the Area's chief assets. Either Environmental Quality or Regional Development could be emphasized alone in this Area or some mix of the three objectives could be recommended.

Recommended Mixed Objective. The Vermont portion of this Area should have an Environmental Quality with some Regional Development mixed objective. The recreational economy and life style of Vermonters around Lake Champlain requires the retention of high environmental quality. The reasonality of the economy requires some attention to Regional Development.

The New York portion of the Area has two separate objectives: Environmental Quality for the Adirondack Forest Preserve and Regional Development outside of the Preserve. The Preserve requires preservation of its natural and wilderness areas and the area around the Preserve has a low per capita income.

Needs To Be Satisfied. There is abundant water and wildlife in Area 11, but the needs for fish and wildlife are fairly large especially man-days for hunting and access for fishing and hunting. Meeting these needs along with the water recreation and visual and cultural needs will help control the recreators' impact upon the environment and also provide better experiences. Erosion and drainage control of croplands will have fairly large and very rapidly growing needs which, when met in conjunction with some irrigation needs, should help stop the historic decline of agriculture and retain the Area's landscape diversity. Preservation of unique natural and quality landscapes are important visual and cultural needs.

Streambank erosion control and all drainage control needs are also large but are not as important to the Regional Development portion of the mixed objective.

Small publicly supplied water needs and fairly small industrial self-supplied water needs will be important to the mixed objective but well within available water supplies. Industrial self-supplied water will be fairly important but because of the ease of meeting this need it is not as critical as the water quality maintenance and other environment related needs which require more careful attention and large investments. Hydroelectric power generation needs are large and grow fairly rapidly because of the availability of sites that will help satisfy power market needs of the Region.

There is abundant water for power plant cooling needs. The need for freshwater withdrawal and consumption grows moderately and is fairly small. Thermal pollution, however, should be tightly regulated so that needs highly dependent upon the environment can be fulfilled.

Unique natural and agricultural landscape maintenance needs will be very large. Most needs in the Area have a steady growth rate during the planning period, but growth rates of several needs are projected to slacken during the second and third planning periods. These last needs include: rural water supply, agricultural irrigation water, and agricultural erosion control.

Flood damage reduction needs which are relatively large and the commercial navigation needs, where are fairly small will both aid in the Area's economic growth.

Devices. The urban and industrial portions of the Area will need secondary waste treatment plants, separation of combined sewers and stormwater discharge control. Rural and agricultural portions of the Area should have septic tank and nutrient control. Cooling towers will be necessary to control high temperature effluents from power plant cooling facilities. All of these water quality control facilities will be important throughout the planning period to help fulfill the needs closely associated with the environment.

Early land control to meet visual and cultural, fish and wildlife and water recreation needs will be important by protecting the Area's environmental quality through the control of industrial growth and expansion of urban and rural homes. Watershed management will also be important for visual and cultural needs, as well as for flood damage reduction and drainage control. The Area has inadequate transportation facilities for tourists, so overland transportation will be important to recreation needs. Biological management devices, insect control and site facilities, will be important as they help meet the fish and wildlife, health and visual and cultural needs respectively. These biological devices, while individually rather small, will be key in helping land control devices meet water recreation needs.

Because there is abundant water flow in Area 11, withdrawal facilities such as river intakes and wells will be the most important devices used in this Area to meet publicly supplied water, industrial self-supplied water, rural water supply, irrigation and power plant cooling needs. Small amounts of reservoir storage will be needed for agriculture irrigation, flood damage reduction and publicly supplied water; pipelines for publicly supplied water; and intake and pumping facilities for publicly supplied and industrial self-supplied water.

Flood plain management will be utilized to meet most flood damage reduction needs of the Area as the local population favors that approach. Some minor water-way management will be necessary, most of it being channel improvements and recreation boating facilities for navigation needs.

Benefits. Fulfillment of fish and wildlife, water recreation, visual and cultural, recreational boating and water quality maintenance needs will bring important economic benefits to the Area by aiding the recreation and tourist industry.

Fulfillment of the water withdrawal needs will help the Area's economy but only a few of the investments for these needs are large in this Area. Hydroelectric power generation is a large need that should consistently provide regional economic benefits.

Increased benefits will arise from water recreation needs by the fulfillment of drainage control and irrigation water needs which will help retain higher quality and diversified landscape. Some additional benefits will also come from fish and wildlife, visual and cultural and water recreation needs through reduced costs from the multiple use of lands acquired by purchase or easement or set aside by zoning.

Costs. Visual and cultural costs are highest in 1980 to gain control of land early in order to fulfill visual and cultural needs at a reasonable cost. Water quality maintenance needs have the highest costs in the Area because of the amount of waste treatment required to maintain water quality, and will be even higher when costs of nutrient control are added. Power plant cooling costs will be fairly high in 2000 and 2020 when more expensive cooling devices and non-condensing facilities are needed to reduce thermal effects and excessive water withdrawal. Water recreation costs are among the highest in the Area in these later target years when a significant increase in visitor days is expected. Publicly supplied water needs are small as are most of the other withdrawal needs. Hydroelectric power costs will be fairly large, however, and they will begin in the middle planning period as large investments are made to take advantage of economical sites while affecting the environment as little as possible.

Alternative Programs. National Income could be emphasized alone in the Area's mixed objective. Power plant cooling water devices would not include non-condensing facilities nor cooling towers. This

would require very large increases in withdrawals and consumption of cooling water. Water recreation needs would fall slightly as investments to provide quality experiences would be drastically reduced and eliminated for land transportation. Less attention to water quality maintenance would exclude the use of research, septic tank control and separation of combined sewers. The use of flood plain and watershed management for upstream flood damage reduction would be reduced in the Area as river projects and storage would be increased. Cropland drainage and erosion control and cropland irrigation water needs and costs would be reduced. The types of land controls would be changed to lower costs for visual and cultural needs. This would lessen the security, preservation and maintenance of quality landscapes.

Primary emphasis could be given to Regional Development in this Area's mixed objective. Visual and cultural needs and devices would remain the same but there would be an increase in forestland drainage control and commercial navigation; a small increase in power plant cooling needs; and decreased use of flood plain management. The water consumption needs of agriculture irrigation and power plant cooling would also increase. This would allow the Area's industry to make fuller use of the Area's natural resources. Agricultural irrigation needs would substantially increase so as to provide a competitive advantage. Power plant cooling water withdrawal needs would be larger and fewer cooling towers used as no non-condenser devices would be used. This would provide more economical generation of power. Fewer water quality maintenance devices would be used. The accomodations made, in this respect, for industry would be tempered by the value inherent in the protection of basic recreational resources. Upstream flood damage reduction needs would be primarily met with reservoirs and river projects rather than the more economically restrictive flood plain management and watershed management. Streambank erosion control needs and costs would be reduced.

Emphasizing Environmental Quality for Area 11 would require the least changes in the recommended program. Publicly supplied and industrial self-supplied water needs would generally be somewhat lower. Agriculture irrigation water needs would be set at much higher levels to maintain the farm landscape and open space. Power plant cooling needs would be drastically reduced during the later planning periods as use of all water withdrawal and consumptive devices would be greatly reduced. These reductions would entail significant increases in investment costs for generation by non-condenser methods. Hydroelectric power needs would be the same but less efficient sites would be developed to minimize environmentally blighting effects. Upstream flood damage reduction needs would be met by complete reliance on flood plain and watershed management at lower costs and with greater contribution to the ecology and environment. Water recreation needs would be slightly larger and costs would be greatly increased to attain quality experiences

AREA 11

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020	
Publicly Supplied Water (mgd)	51	66	94	136	
Industrial Self-Supplied Water (mgd)	100	160	250	380	
Rural Water Supply (mgd)	17	21	24	24	
Irrigation Water: agriculture (1000 afy)	1	14	45	45	
non-agriculture (1000 afy)	1	7	11	18	
Power Plant Cooling: withdrawal, saline (cfs)					
brackish(cfs)					
fresh (cfs)	40	40	75	165	
consumption, brackish(cfs)					
fresh (cfs)	1	1	42	97	
Hydroelectric Power Generation (mw)	1200	1200	4200	8500	
Navigation: commercial (m. tons annually)	1.2	1.5	2.1	3.1	
recreational boating (1000 boats)	23	29	45	66	
Water Recreation: visitor days (m.)	x	19	29	46	
stream or river (miles)	x	58	84	112	
water surface (1000 acres)	x	17	24	34	
beach (acres)	x	180	260	320	
pool (m. sq. ft.)	x	3.3	4.6	5.8	
land facilities (1000 acres)	x	5.5	7.7	10.1	
Fish & Wildlife: sport fishing man-days (m.)	3.8	4.2	4.8	5.6	
surface area, lake (acres)					
stream(acres)	x	0	100	500	
access, fresh (acres)	x	62	152	274	
salt (acres)					
anadromous (acres)					
piers (1000 feet)					
hunting man-days (m.)	2.2	2.3	2.6	3.0	
access (1000 sq. mi.)	x	0.0	0.9	1.7	
nature study man-days (m.)	0.70	0.78	0.90	1.05	
access (1000 acres)					
Water Quality Maint.: non-industrial (m. PEs)	0.51	0.59	0.67	0.79	
industrial (m. PEs)	0.89	1.50	2.48	4.24	
Flood Damage Reduction:					
avg. ann. damage, upstream (m.$)	0.8	1.1	1.6	2.9	
mainstream (m.$)	6	9	17	34	
tidal & hurricane (m.$)					
Drainage Control: cropland (1000 acres)	140	210	350	410	
forest land (1000 acres)	x	0	14	56	
wet land (1000 acres)					
Erosion Control: agriculture (1000 acres)	560	780	940	960	
urban (1000 acres)	170	200	250	300	
stream bank (mi.)	x	30	90	150	
coastal shoreline (mi.)					
Health: vector control and pollution control	x	x	x	x	
Visual & Cultural:					
landscape maintenance, unique natural(sq.mi.)	2400	4500	4500	4500	
unique shoreline (mi.)					
high quality (sq.mi.)	x	250	500	750	
diversity (sq.mi.)	x	50	100	150	
agriculture (sq.mi.)	x	1600	1600	1600	
landscape development, quality (sq.mi.)					
diversity (sq.mi.)					
metro. amenities (mi.)					
" " (sq.mi.)					

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	63	85	108	66	94	136	66	95	137
	160	240	330	160	250	380	160	270	420
				21	24	24			
	66	218	259	2	3	3	66	218	218
	7	12	18	7	11	18	7	12	18
	40	0	0	40	4000	8500	40	1450	2600
	1	0	0	1	34	75	1	65	112
				1200	4200	8500			
	1.3	1.4	1.6	1.5	2.1	3.1	1.6	2.4	3.9
				29	45	66			
	20	31	48	17	28	44	20	32	48
	141	203	272	47	67	90	69	100	134
	42	62	85	11	16	23	22	32	45
	340	480	610	100	140	180	270	380	460
	6.0	8.4	10.7	1.9	2.6	3.6	4.6	6.6	8.0
	20.4	28.7	37.9	3.7	5.2	7.2	7.2	10.1	13.0
				4.2	4.8	5.6			
				0	100	500			
				62	152	274			
				2.3	2.6	3.0			
				0.0	0.9	1.7			
				0.78	0.90	1.05			
				0.59	0.67	0.79			
				1.50	2.48	4.24			
				1.1	1.6	2.9			
				9	17	34			
	210	350	410	180	290	260	210	350	410
	0	14	56	0	14	56	14	56	182
	780	940	960	660	730	750	780	940	960
	200	250	300	170	190	210	200	250	300
	30	90	150	10	20	40	20	50	80
	x	x	x	x	x	x	x	x	x
	4500	4500	4500	4500	4500	4500	Same	as	EQ
	250	500	750	250	500	750	Same	as	EQ
	50	100	150	50	100	150	Same	as	EQ
	1600	1600	1600	1600	1600	1600	Same	as	EQ

AREA 11

DEVICES-incremental	MIXED OBJECTIVE Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)		12*	68*	28*
mainstream (1000 af)		0*	2.6*	29.9*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	51	90	115
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		16*	23*	7*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	7	16	31
waste treatment plants				
secondary (85%) (m. PE removed)	WQ	1.8	0	0
secondary (90%) (m. PE removed)	WQ	0	2.9	4.5
advanced (95%) (m. PE removed)				
effluent irrigation				
nutrient control	WQ	x	x	x
stormwater discharge control	WQ	x		
acid mine drainage control				
septic tank control	WQ	x	x	x
separate combined sewers	WQ	x		
Pumped Storage	HPG		x	x
Desalting Facilities				
Monitoring Facilities	WQ	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	12	31	27
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	2.0	0.5	2.5
flood control channels (mi.)	FDR	0.5	1.5	9.0
Watershed Management (1000 acres)	FDR,Drn,VC,FW	240	450	480
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn,FW	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig	53	131	33	Irrig	1.1	0.5	0	Irrig	53	121	0
PS	1.1	4.2	0.4	PS	1.1	5.4	0.7	PS	1.1	5.6	0.6
Pow**	50	74	85	Pow**	51	90	115	Pow**	55	99	136
Rur**	32	51	31	Rur**	21	28	33	Rur**	32	57	37
WQ	x	x	x					Pow			
PS	6	13	17	PS	7	16	31	PS	7	17	31
				WQ	1.8	0	0				
				WQ	0	1.1	4.5				
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
WQ	x			WQ	x			WQ	x		
WQ	x	x	x								
WQ	x										
				HPG		x	x				
FDR,VC	23	62	52	FDR,VC	1	x	1	FDR,VC	1	x	1
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	1.0	0	0	FDR	3.0	1.0	5.0	FDR	4.0	3.0	7.0
FDR	0	0	0	FDR	1	3	18	FDR	4	18	4
FDR,Drn,VC	430	860	860	FDR,Drn,VC	40	30	110	FDR,Drn,VC	80	90	130
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	1850	150	150
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)				
easements (sq.mi.)	VC, FW	150	150	150
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC, FW	2000	0	0
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW, WQ	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ		x	
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	Rec	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	7	2	9
Rehabilitation of Dams	Rec,FW	x	x	x
Well Controls	Hlth	x	x	x

AD-A036 617 CORPS OF ENGINEERS NEW YORK NORTH ATLANTIC DIV F/G 8/6

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. ANNEX 1.(U)

MAY 72

UNCLASSIFIED NL

3 OF 4

AD
A036617

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	1850	150	150	VC, FW	850	0	0	Same	as	EQ	
VC, FW	150	150	150	VC,FW	0	0	0	"	"	"	
VC,FW	2000	0	0	VC,FW	1600	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	1600	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x					Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ		x									
Pow		x	x								
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	0	0	0	FDR	14	4	17	FDR	18	6	53

AREA 11

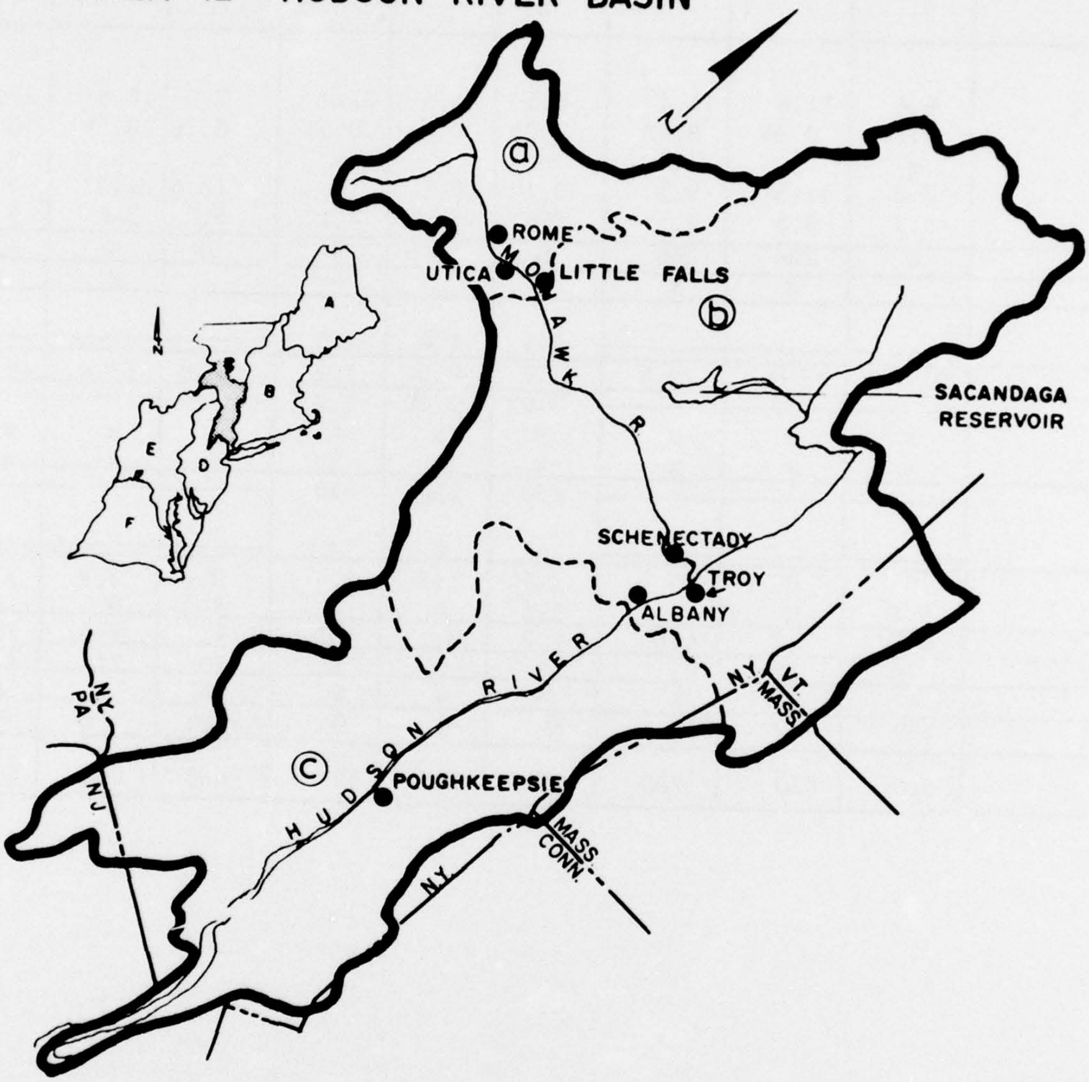
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	2.1*	12.2*	4.3*	
mainstream	0*	4.1*	23.6*	
wells	8.7*	12.4*	4.3*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	8.5	14.4	25.1	
industrial self-supplied water	0.24	0.44	0.54	
rural water supply	x	x	x	
irrigation, agriculture	2.9	6.6	0	
nonagriculture	5.0	3.5	4.6	
Power Plant Cooling Water	0	31	74	
Hydroelectric Power Generation		x	x	
Navigation: commercial				
recreation	0.4	1.4	1.5	
Water Recreation	7.8	32.1	25.4	
Fish and Wildlife: fishing	0.92	1.30	1.73	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	150	230	370	
advanced				
other ≠	91	0	0	
Flood Damage Reduction: upstream	0.8	0.9	1.7	
mainstream	5.8	0	0	
Drainage Control	4.6	9.7	6.0	
Erosion Control	26	23	11	
Health	x	x	x	
Visual and Cultural	130	18	18	
Summation of Available Estimated Costs	450	400	570	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	3.9	9.2	2.6	0.04	0.04	0	3.9	9.2	0
	3.2	6.8	1.1	4.1	8.7	1.9	4.1	8.7	1.9
	2.6	3.8	2.4	1.6	1.9	2.3	2.6	4.1	2.4
	6.6	11.6	15.4	8.5	14.4	25.1	8.5	14.6	25.1
	0.24	0.36	0.42	0.24	0.44	0.54	0.26	0.48	0.55
	x	x	x	x	x	x	x	x	x
	13.8	32.3	9.2	0.1	0.1	0	13.8	32.3	0
	5.2	3.5	4.5	5.0	3.5	4.6	5.0	3.6	4.5
	0	104	260	0	0	0	0	36	66
		x	x		x	x		x	x
				0.4	1.4	1.5			
	61.8	58.0	79.9	1.7	0.5	1.2	13.8	63.6	49.6
				0.92	1.30	1.73			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				150	230	370			
				91	0	0			
	0	0	0	1.6	1.8	3.4	3.4	3.7	5.7
	5.8	0	0	5.8	0	0	5.8	0	0
	3.7	7.7	4.8	2.2	6.2	4.8	4.1	8.5	7.0
	26	23	11	4	6	5	25	21	9
	x	x	x	x	x	x	x	x	x
	130	18	18	55	0	0	Same	as	EQ
	510	510	780	330	280	420	460	460	560

AREA 12 HUDSON RIVER BASIN



AREA 12

Hudson River Basin. Area 12 includes all of the Hudson River drainage and lies mostly within the State of New York with small portions in New Jersey, Vermont, Massachusetts and Connecticut. The Area is divided into three sub-areas and includes 13,366 square miles. Sub-area a includes the drainage of the Mohawk River above Little Falls, New York. The drainage of the Hudson River above Albany, New York, and the remainder of the Mohawk River drainage comprise sub-area b. The Hudson River drainage below Albany to the Atlantic Ocean makes up sub-area c.

The Area's topography includes significant amounts of steep and rolling hills and undulating land with a small amount of mountains. Landscape is equally diverse with large amounts of forest-wildlands, town-farm and farm units and lesser amounts of forest-town and city units. Over half of the Area is of medial visual quality, one-fourth is high and the remainder is low. The wildlands of the Adirondack and Catskill Mountains and the agriculture of the Great Valley provide a great deal of landscape diversity.

The amiable climate and fertile soils of the Hudson Valley stimulated early settlement and the development of dairy farming, livestock and fruit farming. Light manufacturing has become increasingly important and is responsible for heavy population concentrations around Utica, Rome, Albany, Schenectady and Troy, the larger towns of the Area.

The population of the Area in 1960 was 2 million. The 1960 densities ranged from a low of three people per square mile in Hamilton County to 6,757 per square mile in Albany County. The Area had 147 people per square mile and the sub-area densities were 245 people per square mile for a, 126 for b and 151 for c. The population is expected to increase to five million by 2020.

Per capita income in the Area was at the national average in 1959 and is projected to be 1% above that average by 1980 and continue at that level through 2020.

The 1960 employment of 731,600 is expected to increase to two million by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and public administration. Employment is expected to decrease in agriculture, forestry and fisheries; mining; contract construction; food and kindred products; textile mill products; apparel and other textiles; printing and publishing; and petroleum and coal products.

The Hudson River is presently regulated by over 2 million acre-feet of storage. Several large reservoirs in the upper basin, such as Sacandaga and Indian Lake, are multiple purpose. Uses include flood control, navigation, municipal supply, recreation and power. Most storage in the remainder of Area 12 is used for municipal supply.

Existing navigation projects provide a system for shallow-draft vessels extending from the Port of New York to the Great Lakes, to Lake Champlain and on up to the St. Lawrence River. Major reaches near population and industrial centers are seriously degraded by pollution, particularly the upper and middle portions of the Mohawk River, the Hudson River below Albany, New York, and the lower end of the Hudson River.

Average annual runoff in Area 12 is approximately 13,190 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,400 m.g.d., and the corresponding seven-day minimum is about 55% of this total, or 1,325 m.g.d. (See Appendix C). The addition of 96 m.g.d. as an allowance for consumptive losses and 840 m.g.d. developed for export to Area 13, results in an existing firm resource available for use of about 2,261 m.g.d., or 17% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 7,838 m.g.d., or 59% of the average runoff. Potential sources which would develop the increase of 5,577 m.g.d., include major storage, accounting for 61% of the increase; upstream storage, 28%, and ground water development, 11%.

Possible Alternative Planning Objectives. The full range of NAR planning objectives can be considered for Area 12. There are no significant portions of the Area which have been so committed to a particular type of development as to preclude emphasis of any one of the objectives. The sub-areas are also quite similar and planning objectives could be recommended either for the Area as a whole or for each sub-area separately.

Recommended Mixed Objective. It is recommended that Regional Development be emphasized with Environmental Quality in Area 12. The Adirondack Forest Preserve should have only an Environmental Quality emphasis. This mixed objective means maintaning a high level of water resources investments to aid the Area's economy and to aid those people who are chronically poor. This mixed objective mix also means applying constraints to these levels of economic investment; and it means the use of required water management devices that can protect and enhance the Area's landscape and recreational resources, especially in the Adirondack Park and in the rural, farm and wilderness portions of the Area.

Needs To Be Satisfied. Publicly supplied water, industrial self-supplied water and water quality maintenance are large and important needs that must be fulfilled to attain the levels of economic productivity envisioned in meeting the recommended mixed objective. Maintenance of the Hudson River salinity front below present water intakes is a part of these needs. Water quality maintenance needs and industrial self-supplied water needs will increase at a steady rate in each time period while publicly supplied water needs will grow rapidly. Power plant cooling withdrawals and consumptive needs will have a large increase throughout the planning period but at a declin-

ing rate of growth after the very large increase during the first planning period. Increased power plant efficiencies and the inclusion of non-condensing facilities will account for this decreasing of growth rate.

Water recreation needs will be fairly large and will grow fairly rapidly and be difficult to fulfill. Fish and wildlife needs are only moderate. The very large visual and cultural needs include maintenance of agricultural, high quality, unique and diverse natural landscapes and development of metropolitan amenities. Fulfilling these needs will create opportunities for low density recreation and, thus, high value outdoor experiences. Recreational boating needs will be fairly large and contribute to local income. These recreational and environmental experiences are required for a greater than average economic expansion and their fulfillment is dependent upon fulfilling the key water quality maintenance needs of the Area. Additional recreational pressures from large urban centers in adjacent Areas will add to this need especially in sub-area c. Irrigation needs will be large in this Area to aid economic growth and landscape maintenance.

Hydroelectric power generation needs will be large due to the need for economical peaking power in the Regional market served by Area 12 and due to the topographic features that provide good sites for pumped storage power facilities. Commercial navigation needs will also be fairly large and grow rapidly throughout the planning period as the waterways of the Area aid Regional Development through inexpensive bulk transportation. Rural water supply needs will be large in this Area.

Flood damage reduction needs are large for the mainstream and upstream regions. Satisfaction of these needs is key to the Area's ability to develop its land resources. The other needs of the Area have a fairly steady rate of growth because of the Area's economic and population growth requiring the more efficient use of land and water resources. These needs include drainage and erosion control and health.

Devices. The most important devices will be: upstream and mainstream reservoirs; withdrawal facilities including fresh and estuarine intakes and wells; and quality control facilities ranging from water treatment plants and waste treatment plants, to septic tank control and the separation of combined sewers. All of these devices will be required in fairly large amounts and their use will grow rapidly throughout the planning period. These devices will help the publicly supplied water, industrial self-supplied water, and water quality maintenance needs to be met which will encourage the Area's economic development and yet these devices can be consistent with the protection and enhancement of the Area's environmental quality.

Additional devices important to meeting the Area's needs are: upstream and mainstream flood plain management; watershed manage-

ment and erosion protection; and navigation channel improvement and debris removal as means to effect a more efficient use of the waterways. These devices will help meet the needs of drainage and erosion control and navigation. They will also partially fill the needs relating to flood damage reduction, visual and cultural, water recreation, and fish and wildlife. The remaining part of these last needs will be fulfilled by Land Management and Biological devices and quality control facilities.

Power plant cooling needs will require fresh and estuarine intakes for water withdrawal as well as the quality control facilities such as cooling towers and non-condensing power facilities. These devices will help the Area continue with its economic development within the constraints required to protect the environment. Flood damage reduction needs will require upstream storage but no mainstream storage since flood plain management along with a few river projects is likely to be effective on the mainstream. State policy is to give local entities the option for this approach and its acceptance is increasing. Education may help the acceptance of flood plain management in this Area.

Benefits. Meeting visual and cultural needs will result in large environmental benefits, produce more participation in water recreation and aid wildlife productivity in this Area. Many of the devices employed to meet these visual and cultural needs will also be complementary to and reduce the costs of erosion control.

Water quality maintenance will produce large benefits, particularly in sub-area c where surface supplies are most degraded. The improvement in water quality will enhance its use for most purposes and eliminate both an eyesore and a health hazard.

Water recreation and fish and wildlife benefits should be fairly high. The existing thruway and road network connecting urban centers with rural areas provides comparatively easy access to water recreation and fish and wildlife facilities. This network will aid in the fulfillment of these needs and will increase the economic return of these needs to the area.

Important economic benefits will accrue to underdeveloped parts of the Area from satisfying hydroelectric power generation, navigation, publicly supplied and industrially self-supplied water and flood damage reduction needs. Benefits will be realized through the use of multi-purpose facilities which can provide the foundation for continuing economic growth in the Area. Such multiple-purpose benefits will be from agricultural irrigation water, that will help maintain the Area's landscape diversity and from low flow augmentation that will help maintain the salinity front below present water supply intakes.

Costs. Publicly supplied water and water development costs, particularly in the first planning period, are key expenditures to the achievement of the Regional Development objective. The large costs for fulfillment of this need result from its early satisfaction and from taking complete advantage of available sites for storage and conveyance.

Water recreation costs are high because of the close proximity of the Area's high quality landscape and other natural resources to several metropolitan centers and because of the aid that water recreation can give to the Area's economy.

Costs of maintaining water quality standards are also high because of the amount and types of necessary treatment. The need for advanced waste treatment in the future will add heavily to these costs during the last planning period.

The costs needed to satisfy visual and cultural needs are relatively high, though they decrease slightly after the first time period and are mainly comprised of costs for fee simple purchase, easements and tax incentive subsidy and/or zoning.

Navigation costs are generally high and are incurred to aid industrial development. Power plant cooling costs and hydroelectric power generation costs will be high in order to satisfy electric generation needs with a minimum adverse effect on the environment.

Some uncertainties are involved in the program needs and costs for this Area. These concern the competition for the Area's resources by industrial growth and technology and visual and cultural and water recreation needs. High water quality maintenance costs, for instance, may result if industrial growth is found to extensively interfere with the environmental quality of the Area.

Alternative Program. If Environmental Quality were chosen to be primarily emphasized throughout Area 12, needs for streambank erosion control, irrigation water, and water recreation would be larger than the needs in the recommended program; those of industrial self-supplied and publicly supplied water, and commercial navigation, would be lower; and those of visual and cultural and flood damage reduction. Agriculture irrigation would be emphasized even through the last planning period for maintenance of landscape diversity. The water recreation experience would be improved by greater use of reservoirs for this purpose in the last planning period. Power plant cooling needs would be met by lower fresh water and higher brackish water withdrawals and consumption at much higher costs to aid the environment. Upstream flood damage reduction would be accomplished by increased management of the flood plains and watersheds with reduced dependance on upstream reservoirs and river projects. Visual and cultural needs would be met by greater use of purchase lease and deed restriction and less use of zoning and/or tax incentives at greater costs but more assurance of control.

If National Income were chosen, the needs for industrial self-supplied, publicly supplied and irrigation water, commercial navigation, water recreation, cropland drainage and agricultural and urban erosion control would be lower while the needs for water quality maintenance, power plant cooling, visual and cultural and flood damage reduction would be met by a different mix of devices. Streambank erosion control needs would be much smaller. Irrigation of all types would be reduced especially for agricultural lands. Water quality maintenance needs would be met by greatly reduced use of septic tanks and nutrient control. Agriculture and urban erosion control and cropland drainage control would be diminished to make for a more economically efficient agriculture industry. The needs for water recreation would be reduced because of recreation being a less efficient investment. The visual and cultural landscape would be preserved primarily by less expensive zoning and some purchase lease and deed restriction and less use of easements and fee simple purchase. Commercial navigation needs would be slightly reduced. Upstream flood damage reduction would utilize more reservoirs and local projects and less flood plain and watershed management. Power plant cooling needs would not include the use of non-condensing facilities. Fresh and brackish water withdrawals for this need would be larger in the last two time periods along with slight increases in consumption and decreased costs.

If Regional Development were chosen, satisfaction of the needs of agricultural irrigation would undergo the greatest change as compared to the recommended program. Agricultural irrigation needs and costs would be greatly enlarged to increase agricultural output. Non-condensing facilities would not be used which would increase needs for power plant cooling and decrease costs. All withdrawals for this need will increase in the last two time periods as will brackish consumption. Commercial navigation would have slightly larger needs over the whole planning period to give an impetus to local industry by offering better service. Water quality maintenance needs would be met by greatly reduced use of septic tanks and nutrient control devices. Forest drainage control needs would be increased to make lumbering a more efficient industry. Upstream flood plain damage reduction needs would be met by less flood plain and watershed management and increased use of upstream reservoirs and river projects that allow increased development of the flood plains. Visual and cultural needs would be met by different devices to attain more certain control of landscapes. This would include less use of zoning and/or tax incentives and increased use of purchase lease and deed restriction.

AREA 12

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020	
Publicly Supplied Water (mgd)	230	320	520	820	
Industrial Self-Supplied Water (mgd)	300	500	900	1600	
Rural Water Supply (mgd)	41	56	73	58	
Irrigation Water: agriculture (1000 afy)	9	41	82	82	
non-agriculture (1000 afy)	5	19	32	48	
Power Plant Cooling: withdrawal, saline (cfs)					
brackish (cfs)	1500	10800	13300	5900	
fresh (cfs)	400	1500	1900	2300	
consumption, brackish (cfs)	10	100	120	50	
fresh (cfs)	4	10	150	410	
Hydroelectric Power Generation (mw)	400	3400	7900	20500	
Navigation: commercial (m. tons annually)	29	36	57	92	
recreational boating (1000 boats)	70	130	190	320	
Water Recreation: visitor days (m.)	x	68	112	202	
stream or river (miles)	x	207	313	429	
water surface (1000 acres)	x	51	78	111	
beach (acres)	x	977	1479	2340	
pool (m. sq. ft.)	x	17	26	40	
land facilities (1000 acres)	x	24	36	55	
Fish & Wildlife: sport fishing man-days (m.)	2.5	2.7	3.3	4.0	
surface area, lake (acres)					
stream (acres)					
access, fresh (acres)	x	30	110	220	
salt (acres)					
anadromous (acres)	x	32	44	58	
piers (1000 feet)					
hunting man-days (m.)	1.3	1.4	1.6	1.9	
access (1000 sq. mi.)	x	0.4	1.2	2.1	
nature study man-days (m.)	2.4	2.6	3.1	3.7	
access (1000 acres)	x	9.7	25.7	43.7	
Water Quality Maint.: non-industrial (m. PEs)	2.0	2.3	2.8	3.4	
industrial (m. PEs)	4.2	7.7	14.4	28.0	
Flood Damage Reduction:					
avg. ann. damage, upstream (m.$)	4	6	12	21	
mainstream (m.$)	8	12	22	44	
tidal & hurricane (m.$)					
Drainage Control: cropland (1000 acres)	70	100	170	200	
forest land (1000 acres)	x	0	12	47	
wet land (1000 acres)					
Erosion Control: agriculture (1000 acres)	1700	2100	2300	2300	
urban (1000 acres)	580	630	730	890	
stream bank (mi.)	x	16	48	80	
coastal shoreline (mi.)					
Health: vector control and pollution control	x	x	x	x	
Visual & Cultural:					
landscape maintenance, unique natural (sq. mi.)	3900	3900	3900	3900	
unique shoreline (mi.)					
high quality (sq. mi.)	3400	3400	3400	3400	
diversity (sq. mi.)	x	800	1600	2400	
agriculture (sq. mi.)	x	2600	2600	2600	
landscape development, quality (sq. mi.)					
diversity (sq. mi.)					
metro. amenities (mi.)					
" " (sq. mi.)	x	50	50	50	

AREA 12

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
300	450	680	320	510	820	320	520	820
500	800	1300	500	900	1400	500	900	1600
			56	73	58			
92	273	347	28	34	34	92	273	273
20	33	49	19	32	49	19	33	49
11200	16000	8000	11200	13800	6600	11200	14300	7000
1100	1200	400	1100	5400	7500	1100	2800	4700
100	140	120	100	130	60	100	130	110
20	60	190	20	140	420	20	140	350
			3400	7900	20500			
34	51	79	35	56	89	36	58	94
			130	190	320			
66	109	202	58	95	177	68	112	202
419	635	872	138	210	288	207	313	429
101	154	220	24	38	54	51	78	111
1250	1890	3090	350	530	880	980	1480	2340
22	33	54	7	10	17	17	26	40
69	101	161	12	18	30	24	36	55
			2.7	3.3	4.0			
			30	110	220			
			32	44	58			
			1.4	1.6	1.9			
			0.4	1.2	2.1			
			2.6	3.1	3.7			
			9.7	25.7	43.7			
			2.3	2.8	3.4			
			7.7	14.4	28.0			
			6	12	21			
			12	22	44			
100	170	200	90	140	170	100	170	200
0	12	47	0	12	47	12	47	152
2100	2300	2300	1900	2000	2000	2100	2300	2300
630	730	890	590	650	730	630	730	893
32	96	160	6	22	38	16	48	80
x	x	x	x	x	x	x	x	x
3900	3900	3900	3900	3900	3900	Same	as	EQ
3400	3400	3400	3400	3400	3400	Same	as	EQ
800	1600	2400	550	650	750	Same	as	EQ
2600	2600	2600	2600	2600	2600	Same	as	EQ
50	50	50	0	50	50	Same	as	EQ

AREA 12

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	VC	72*	36*	637*
mainstream (1000 af)	VC,WQ	10*	110*	370*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	210	430	680
brackish (mgd)	Ind	7	10	14
estuarine (mgd)	Pow	x	x	x
ocean (mgd)				
wells (mgd)		4*	56*	44*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)		0*	270*	1020*
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	38	107	221
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	9	16	29
advanced (95%) (m. PE removed)	WQ	0	0	1.6
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x		
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x		
Pumped Storage	HPG	x	x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	12	82	104
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	13	1	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	210	410	410
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav		x	x
debris removal	VC	x	x	x
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig

ϕ̸ Also includes the following purposes: VC,Rec

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	62	140	56	Irrig,VC	14	5	0	Irrig,VC	62	136	0
PS,WQ †	104	40	3	PS,VC,WQ	126	48	4	PS,VC,WQ	126	51	4
Pow**	190	340	470	Pow**	200	390	590	Pow**	210	430	680
Ind	6	8	7	Ind	6	9	12	Ind	7	10	14
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	81	132	119	Rur**	67	105	133	Rur**	84	151	139
Pow,WQ	x	x	x	Pow		x	x	Pow	x	x	x
PS	31	81	166	PS	38	100	231	PS	38	107	221
				WQ,VC	9	16	29				
				WQ	0	0	1.6				
WQ,VC	x	x	x								
WQ,VC	x			WQ,VC	x			WQ,VC	x		
WQ,VC	x	x	x								
WQ,VC	x			WQ,VC	x			WQ,VC	x		
				HPG	x	x	x				
FDR,VC	20	161	203	FDR,VC	4	3	5	FDR,VC	4	3	5
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	12	0	0	FDR	13	2	0	FDR	14	1	0
FDR,Drn,VC	410	810	810	FDR,Drn,VC	160	30	x	FDR,Drn,VC	20	20	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav		x	x	Nav		x	x
Rec,Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	450	450	400
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)	VC,FW	0	0	0
easements (sq.mi.)	VC, FW	400	400	400
deed restrictions (sq.mi.)	VC,FW	0	0	0
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW	2600	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education	FDR	x	x	
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs				
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	45	2	0
Flood Skimming	Ind	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	450	400	400	VC, FW	50	50	50	Same	as	EQ	
VC, FW	2600	0	0	VC, FW	50	0	0	"	"	"	
VC, FW	400	400	400	VC, FW	50	50	50	"	"	"	
VC, FW	100	0	0	VC, FW	0	50	0	"	"	"	
VC, FW	300	0	0	VC, FW	3000	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x	x	x								
Pow		x	x								
Rec			x								
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	32	0	0	FDR	52	7	0	Rec	57	3	0

AREA 12

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE 1980	2000	2020	
Water Development Costs:				
storage, upstream	16.7*	7.4*	89.9*	
mainstream	1.7*	68.8*	74.2*	
wells	23.4*	30.4*	3.3*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	33	86	134	
industrial self-supplied water	1.05	2.06	3.25	
rural water supply	x	x	x	
irrigation, agriculture	5.6	9.4	0	
nonagriculture	12	10	13	
Power Plant Cooling Water	0	75	176	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial	0	80	27	
recreation	3.7	7.2	11.6	
Water Recreation	880	530	900	
Fish and Wildlife: fishing	0.86	1.38	1.70	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	650	1090	1970	
advanced	0	0	700	
other ≠	260	0	0	
Flood Damage Reduction: upstream	6.5	3.8	0	
mainstream	15.3	0	0	
Drainage Control	1.8	2.8	2.8	
Erosion Control	35	33	23	
Health	x	x	x	
Visual and Cultural	157	140	140	
Summation of Available Estimated Costs	2100	2200	4300	

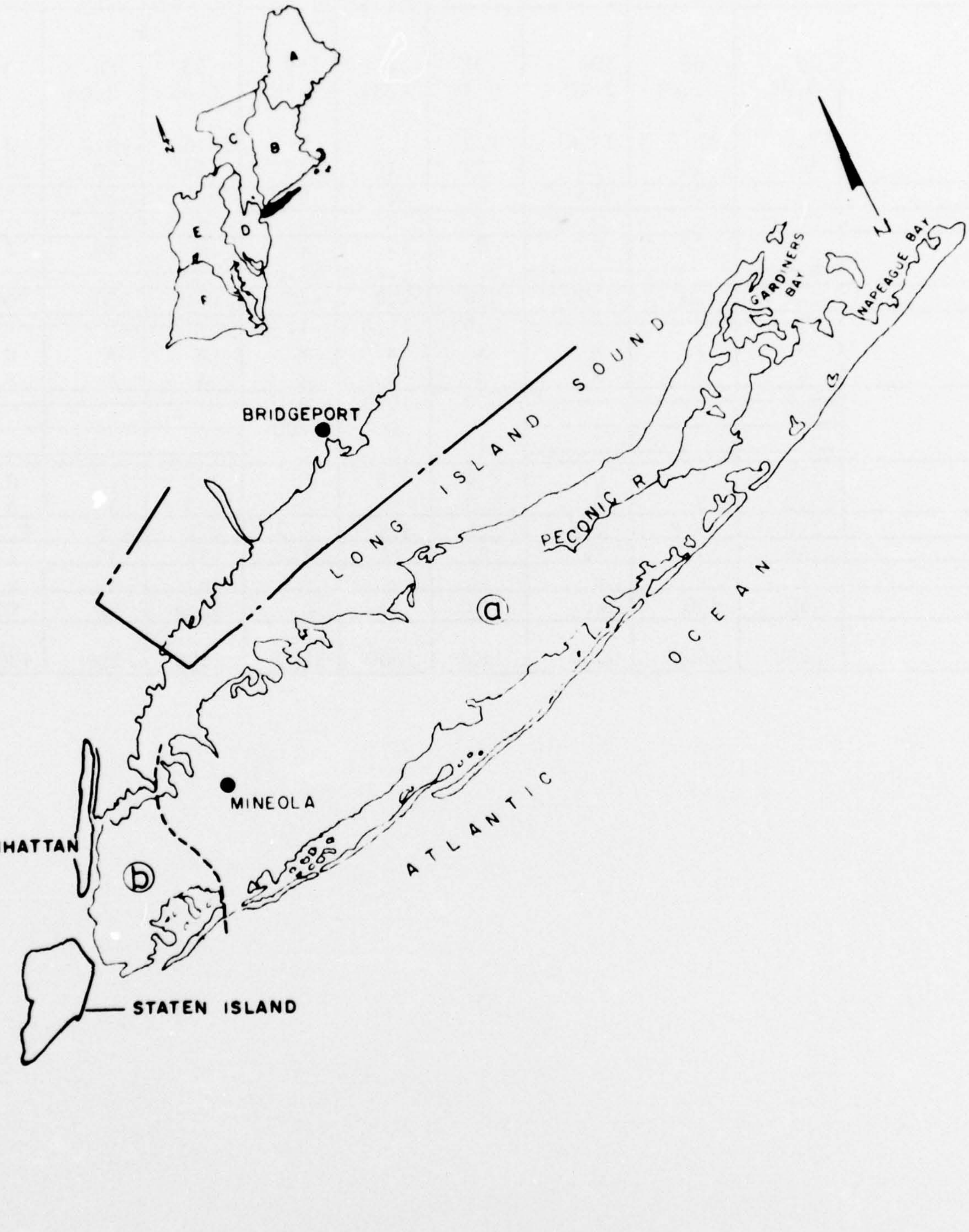
*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

AREA 12

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	4.9	10.7	4.7	0.6	0.4	0	4.9	10.7	0
	61.5	32.9	5.0	74.9	39.9	7.1	74.9	42.5	6.8
	5.7	8.3	7.9	4.2	5.4	8.0	5.7	9.2	8.2
	27	66	104	31	81	149	33	86	134
	0.98	1.61	2.20	0.98	1.85	2.75	1.05	2.06	3.25
	x	x	x	x	x	x	x	x	x
	18.6	40.2	17.6	2.3	1.7	0	18.6	40.2	0
	12	10	13	12	10	13	12	10	13
	0	236	648	0	0	0	0	30	37
	x	x	x	x	x	x	x	x	x
	0	0	0	0	80	27	0	80	27
				3.7	7.2	11.6			
	1230	700	1350	250	210	420	880	530	900
				0.86	1.38	1.70			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				650	1090	1970			
				0	0	700			
				260	0	0			
	5.5	0	0	7.2	7.3	0	7.5	7.7	0
	15.3	0	0	15.3	0	0	15.3	0	0
	1.8	3.8	2.8	1.1	3.1	2.7	2.1	4.5	4.7
	36	35	24	8	14	14	35	33	23
	x	x	x	x	x	x	x	x	x
	469	140	140	43	26	26	Same	as	EQ
	2800	2400	5000	1400	1600	3400	2500	2100	4000

AREA 13 SOUTHEASTERN NEW YORK METROPOLITAN AREA



AREA 13

Southeastern New York Metropolitan Area. Area 13 covers 1,901 square miles and includes the five boroughs of New York, parts of Westchester County, and Long Island's Nassau and Suffolk Counties. The Area is divided into two sub-areas of which a is comprised of Long Island and b is all of New York City and Westchester County. New York City is the nation's most important port, railroad, air transportation and foreign trade center. It is the financial pivot of the United States and contains the largest concentration of financial, trade, professional, education, business and communication services in the world.

The land form in this urbanized Area is undulating. Twenty-one percent of the Area consists of a farm-forest pattern and the remainder is in city. The landscape quality in the Area is low and is limited to portion's of Westchester County's river front and coastline and to eastern Long Island.

New York City became a provincial center by 1650 with a population of 3000. The growth of the city was accompanied by agricultural development on Long Island, in nearby New Jersey and northward along the Hudson. By the early 1800's, New York City was the Nation's largest population center and had the largest port in tonnage handled. The last century has seen the City grow northward along the Hudson, widen southward in New Jersey, and spread out toward the agricultural areas of Long Island.

The population of the Area in 1960 was 10.6 million. The population density of the Area was 557 people per square mile in 1960 and ranged from 24,723 per square mile in New York County to 723 per square mile in Suffolk County. The sub-area population densities were 17,079 per square mile in a and 1,408 per square mile in b. The projected population in 2020 is 15.5 million.

Personal income per capita was 39 percent above the national average in 1960, but its relative standing is expected to decline by 2020 to 18 per cent above the national average.

The 1960 employment of 4.3 million is expected to increase to 6.8 million by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; transportation, communication and public utilities; and finance, insurance and real estate. Employment is expected to decrease in agriculture, forestry and fisheries; mining; food and kindred products; textile mill products; apparel and other textiles; lumber, wood products and furniture; and services.

Water is generally not available in Area 13, except for the ground water sources that supply sub-area a. Supplies for sub-area b must be imported from Areas 12 and 15. Municipal and industrial pollution seriously degrade the quality of the Area's water, particularly in sub-area b.

Average annual runoff in Area 13, including sub-surface outflow of ground water, is approximately 1,900 m.g.d. About 910 m.g.d. of this represents surface outflow, most of which is derived from ground water. The existing minimum monthly streamflow (shortage index 0.01) is 220 m.g.d., and the corresponding seven-day minimum is about 85% of this total, or 185 m.g.d. (See Appendix C). Due to the unique hydrologic and deologic nature of Long Island, the developed ground water resource is not generally reflected in surface outflow measurements. Accordingly, the assumed existing available resource includes an allowance for this which is based on the estimated 1965 ground water use including consumption. This results in an existing firm resource available for use of 623 m.g.d. This does not include about 1,380 m.g.d., which can be imported into the Area for New York City.

The practical limit of development within the Area, based on potential yield of additional ground water, including 300 m.g.d. of anticipated artificial recharge, would provide a maximum available resource of 1,212 m.g.d., or 64% of the average runoff.

Possible Alternative Planning Objectives. The range of planning objectives is somewhat restricted in Area 13. The high per capita income level would indicate that Regional Development is not desirable as an objective for the Area as a whole, though it could be emphasized in local pockets of proverty in each of the sub-areas. The high degree of development of buildings and roads could likewise limit the amount of emphasis to be placed on Environmental Quality, especially in sub-area b, but it would be desirable to improve and maintain landscape and water quality in the urbanized portions of sub-area a. The differences in population density, industrial concentration, and landscape type and quality point toward different planning objectives for each sub-area, or for an Area objective with localized sub-area objectives.

Recommended Mixed Objective. It is recommended that National Efficiency and Environmental Quality be emphasized together as Area 13's mixed planning objective. The primary result of this mix will be a water management program which aids the continued economic growth of the Area while providing as much increase as possible in the Area's environmental quality. This environmental aid would be achieved by generally achieving the National Efficiency levels of the Area's needs through the use of Environmental Quality related devices.

Needs To Be Satisfied. The most important needs to be satisfied will be publicly supplied water, water quality maintenance, recreational boating, water recreation and visual and cultural. The publicly supplied water and water quality maintenance needs are very large and the visual and cultural needs are relatively large. These three needs are expected to be particularly key in achieving this Area's program because of the Area's high population concentrations and projected growth rates. Fulfilling the key visual and cultural needs can help fulfill the health needs of the Area.

Water quality maintenance needs will be high throughout the planning period because of extremely high pollution levels. The satisfaction of this need aids the high urban needs of water recreation, visual and cultural and fish and wildlife. Water quality is especially important in this Area where there are such large quantities of water so close to large populations that need recreation. Industrial self-supplied water needs will increase rapidly in each time frame but are very small because the bulk of the water for industry in this Area is provided from public supplies.

Navigation needs for one of the world's largest ports will also be very large. Recreational boating needs will be very large and grow fairly rapidly. Commercial craft tonnage will increase moderately each time frame. Power plant cooling needs for saline water withdrawal are very large in Area 13 and will also grow moderately. The size of this need is primarily due to the Area's large population and industry which are located near large amounts of easily used saline water.

There will be large water recreation, recreational boating, fish and wildlife, non-agricultural irrigation water and health needs in all planning periods. Water plays a very large part in the lives of the people of Area 13 because of its surrounding most portions of the Area and because of the large number of people who would take advantage of this water if is were of good quality and easily accessible.

The water recreation needs include beach and water surfaces and land facilities. The fish and wildlife needs that can be partially met in the Area include fresh and salt water access, piers, and nature observation. The visual and cultural needs include maintenance of unique shorelines and landscapes diversity and development of metropolitan amenities. There is also a visual and cultural need for drift removal on the waterways of the Area and for water front rehabilitiation and accessibility. The need for rehabilitation and accessability is especially key to the achievement of this Area's mixed objective. Health needs include vector and pollution controls.

Non-agricultural and agriculture irrigation water needs are both large at the present but only non-agriculture needs will remain large. Golf courses and other non-agricultural irrigation needs will continue to grow especially in sub-area a but the large amount of irrigated cropland in that sub-area is expected to be gone entirely by 2000.

Coastal erosion control, especially in sub-area b, and tidal flood damage reduction needs in both sub-areas are very large and coastal erosion control needs grow rapidly. Very little attention has been given to these needs in sub-area b where flood damages from

hurricanes could be extremely large. Urban erosion control needs are presently only moderately large in Area 13, but will be of significance in sub-area a where new suburbs are rapidly growing.

Small needs in this Area include rural water supply, and drainage control.

Devices. Interbasin water transfer and its accompanying devices of pipelines, aqueducts, and pumping stations are most important to Area 13. Wells, water treatment plants, all types of water intakes, and reservoirs will also be needed. These devices, required throughout the planning period, will enable the needs to be met that require dependable water supplies for the Area's large urban complexes. A ground water management program will be necessary for sub-area b and must include recharge of ground water. This program will help maintain streamflows, lake levels, water quality and estuarine environments of the sub-area. Water quality control facilities will be equally important for the fulfillment of water recreation, fish and wildlife and visual and cultural needs. These devices include waste treatment plants with advanced waste treatment used after the second time period and storm water discharge control, nutrient control, separation of combined sewers and septic tank control in all time periods.

Power plant cooling needs will be realized by the use of ocean intakes with off-shore outfalls, supplemented by cooling facilities where feasible to safeguard the quality of estuarine and fresh waters. This will satisfy the mixed objective by providing ample power generation with the least impact on the environment.

Land Management and Water/Land management devices can meet most of the navigation, water recreation, fish and wildlife, erosion control, flood damage reduction, and visual and cultural needs. Among the most important of these devices will be local river and ocean protection projects for meeting the flood damage reduction needs in the early part of the planning period. Offshore facilities, port improvements, drift removal and lightering will be important for commercial navigation in all time periods.

Land control by fee simple purchase and easements along with increased parking and trails in the early time frames would help meet the needs of water recreation, fish and wildlife and visual and cultural. These devices, if implemented early, would provide the base for preserving ecological habitat, for preventing further environmental damage, and for potential rehabilitation and upgrading of waterfront and coastal regions. These devices can not succeed, however, without the key water quality control devices.

Benefits. Substantial benefits to the Area will result from the additional importation of water into the Area since it will enable the fulfillment of the expected large increases in public water supply needs. Many large and different types of benefits will be produced by many needs as a result of maintaining high water quality standards. These benefits include: improvement in fish and wildlife habitat; greater opportunity for water based recreation; decreased possibility of disease transmission; increase in potential for groundwater recharge; and improvement to the visual and cultural environment of the Area. Provision for offshore outfalls for effluents will benefit water quality maintenance programs.

Important benefits will occur by improving fish and wildlife habitat on Long Island. This is due to the large number of recreation man-days that will be gained by using the Biological devices to aid nature observation. Key benefits will be obtained through satisfaction of water recreation and visual and cultural needs because of the present lack of environmental amenities. Navigation improvements will be highly beneficial with channel improvements and debris removal acting as a stimulus to continued high commerce in the Area. Coastal improvements including ocean protection projects for flood damage reduction and coastal shoreline protection for erosion control, will provide benefits for multiple purposes that include navigation, recreation and visual and cultural needs.

Benefits from non-agricultural irrigation, principally golf courses, will be particularly significant in terms of visual and cultural and recreation aspects because of the proximity of the urban population.

Costs. Water quality maintenance costs will be very high due to problems concerned with treatment of wastes from an extremely large population and industry. Many new treatment plants are required to handle the high waste loads. A large proportion of the costs in the first target year, 1980, are allocated to combined sewer control.

Investments for acquisition and preservation of land in a natural state for visual and cultural needs are particularly high in the first planning period because of present deficiencies and the need to take action before pressure for other uses becomes too great. High recreation costs mainly reflect the costs of water surfaces, beaches and facilities which will increase throughout the planning period.

Publicly supplied water and water transfer costs are high in 2000 and relatively high in 2020 because of the costs of meeting the large future needs with impoundment and transmission facilities. There may also be costs to other NAR Areas which supply water for Area 13 because of the loss of their potential reservoir sites and the possible detrimental effects to their visual and cultural environments.

Satisfying fish and wildlife needs could result in an additional cost to navigation because of the problems of safely disposing of spoil from navigation channel improvements.

Alternative Programs. If Environmental Quality were chosen to be primarily emphasized in this Area, the needs of water recreation and erosion control would be much larger; those needs of agricultural irrigation would be somewhat larger; and those needs of publicly supplied and industrial self-supplied water and of commercial navigation slightly lower. The increased emphasis on water recreation would be towards providing quality experiences which would be achieved by development of a larger number of pools and beach areas, and provision of larger amounts of land and facilities at much greater costs. A greater emphasis would be placed on agricultural irrigation and erosion control to gain higher quality visual and cultural experiences. The erosion control increases would include urban, streambank and shoreline erosion. Continued and greater emphasis would be placed on waterfront renewal for visual and cultural needs and debris removal for navigation. No channel improvements would be anticipated for navigation, however which would reduce waterborne activity and navigation expenditures. There would be a reduction in publicly supplied water needs because of lower population and a reduction in industrial self-supplied water needs because of the lower GNP projections.

If Regional Development were to be emphasized in Area 13, the need for water recreation would be significantly larger while those needs of publicly supplied and industrial self-supplied water erosion control, agricultural irrigation, and navigation would only be slightly larger. The water recreation program would be an accelerated version of the recommended program. Many more facilities would be constructed, although not to the degree suggested in the Environmental Quality alternative program above. Power plants would be located to take advantage of the estuary for cooling water during the last planning period. This would allow less saline water to be withdrawn and the use of cooling towers only during the last planning period. Urban, streambank and shoreline erosion control needs would be larger.

If National Income were primarily emphasized there would be a large decrease in the needs and costs of visual and cultural as fewer unique shorelines would be maintained and metropolitan amenities would be delayed until after the first time period. Land would be controlled by less expensive and less sure means. As few reductions as possible would be made in preserving and increasing the Area's amenities, however, because of the close relationship that is to be found between urban economic productivity and the quality of life available to the people. Cooling towers would only be used during all periods for water quality maintenance.

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	1400	1700	2300	3000
Industrial Self-Supplied Water (mgd)	24	33	58	109
Rural Water Supply (mgd)	21	30	30	15
Irrigation Water: agriculture (1000 afy)	19	15	0	0
non-agriculture (1000 afy)	14	27	44	66
Power Plant Cooling: withdrawal, saline (cfs)	9300	10900	18500	33100
brackish (cfs)	0	0	0	0
fresh (cfs)				
consumption, brackish (cfs)	0	0	0	0
fresh (cfs)				
Hydroelectric Power Generation (mw)				
Navigation: commercial (m.tons annually)	60	70	110	170
recreational boating (1000 boats)	380	490	680	1400
Water Recreation: visitor days (m.)	x	110	170	280
stream or river (miles)	x	210	290	360
water surface (1000 acres)	x	45	62	81
beach (acres)	x	700	940	1450
pool (m. sq. ft.)	x	14	18	28
land facilities (1000 acres)	x	24	31	46
Fish & Wildlife: sport fishing man-days (m.)	15	17	21	25
surface area, lake (acres)	x	1200	3400	5900
stream (acres)				
access, fresh (acres)	x	30	76	116
salt (acres)	x	1700	4600	7900
anadromous (acres)				
piers (1000 feet)	x	49	130	224
hunting man-days (m.)	1.0	1.2	1.4	1.6
access (1000 sq. mi.)	x	0.1	0.2	0.3
nature study man-days (m.)	14	16	20	24
access (1000 acres)	x	33	88	153
Water Quality Maint.: non-industrial (m. PEs)	11	13	16	19
industrial (m. PEs)	14	29	53	99
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)				
mainstream (m.$)	0.7	1.0	1.9	3.6
tidal & hurricane (m.$)	32	49	91	176
Drainage Control: cropland (1000 acres)				
forest land (1000 acres)				
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	52	53	53	53
urban (1000 acres)	550	600	690	730
stream bank (mi.)	x	1	4	7
coastal shoreline (mi.)	x	6	20	34
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)				
unique shoreline (mi.)	x	80	80	80
high quality (sq.mi.)				
diversity (sq.mi.)	x	100	100	100
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	60	60	60

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
1700	2000	2500	1700	2300	3000	1700	2300	3000
33	54	96	33	58	109	36	61	122
			30	30	15			
15	0	0	15	0	0	15	0	0
27	44	66	27	44	66	27	44	66
10900	18500	31500	10900	18500	31500	10900	18500	28900
0	0	0	0	0	0	0	0	5000
0	0	0	0	0	0	0	0	70
70	80	90	70	110	170	80	130	210
			490	680	1400			
130	190	320	110	170	280	80	140	270
640	880	1090	210	290	360	320	440	540
163	182	252	45	62	81	86	117	153
1880	2550	3900	700	940	1450	860	1170	1730
32	44	67	14	18	28	17	23	34
119	172	254	24	31	46	48	63	91
			17	21	25			
			1200	3400	5900			
			30	76	116			
			1700	4600	7900			
			49	130	224			
			1.2	1.4	1.6			
			0.1	0.2	0.3			
			16	20	24			
			33	88	153			
			13	16	19			
			29	53	99			
			1.0	1.9	3.6			
			49	91	176			
53	53	53	53	53	53	53	53	53
690	830	880	600	690	730	690	830	880
6	18	30	1	4	7	3	9	15
156	341	397	6	20	34	14	42	70
x	x	x	x	x	x	x	x	x
80	80	80	40	40	40	Same	as	EQ
100	100	100	100	100	100	Same	as	EQ
60	60	60	30	60	60	Same	as	EQ

AREA 13

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	VC	x		
mainstream (1000 af)	VC	x	0	0
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Irrig	5	310	560
brackish (mgd)	Ind	160	230	340
estuarine (mgd)	Pow		x	
ocean (mgd)	Pow	x	x	x
wells (mgd)		150*	210*	290*
Conveyance Facilities				
interbasin diversions, into (mgd)		0*	270*	490*
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	5	309	562
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	37	61	106
advanced (95%) (m. PE removed)	WQ,VC	2.1	3.4	5.9
effluent irrigation	WQ,VC	x	x	x
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x		
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x		
Pumped Storage				
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	VC	x		
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)	FDR	3	2	0
river (projects)	FDR	0	1	0
flood control channels (mi.)				
Watershed Management (1000 acres)	VC	x		
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices				
Waterway Management				
navigation channel improvement	Nav	x	x	
debris removal	VC	x	x	x
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC	x			VC	x			VC	x		
PS,VC	x	480	0	PS,VC	x	660	0	PS,VC	x	670	0
PS,Irrig	4	220	350	PS,Irrig	5	310	560	PS,Irrig	5	310	570
Ind	160	200	200	Ind	160	230	340	Ind	180	260	400
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	100	140	170	Rur**	110	180	250	Rur**	120	180	260
PS	0	220	340	PS	0	300	550	PS	0	300	550
WQ	x	x	x	WQ	x	x	x	Pow,WQ	x	x	x
PS	4	223	345	PS	5	309	562	PS	5	311	566
				WQ,VC	37	61	106				
				WQ,VC	2.1	3.4	5.9				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x			WQ,VC	x			WQ,VC	x		
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x			WQ,VC	x			WQ,VC	x		
VC	x			VC	x	x		VC	x		
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	3	2	0	FDR	3	2	0	FDR	3	2	0
FDR	0	1	0	FDR	0	1	0	FDR	0	1	0
VC	x			VC	x			VC	x		
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
				Nav	x	x		Nav	x	x	
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 13

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	110	0	0
fee simple purchase (buying) (mi.)	VC, FW	80	0	0
purchase lease (sq.mi.)	VC,FW	0	0	0
easements (sq.mi.)	VC, FW	50	0	0
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x		
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ, Pow	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Protect Shellfish	Hlth	x	x	x
Legislation for Urban Erosion Control	Ern	x	x	x
Ground Water Management Program	PS	x	x	x
Sewage Recharge	PS,WQ	x	x	x
Water Front Rehabilitation	VC	x	x	x
Septic Tank Elimination	Hlth	x	x	x
Use of Waste Heat for Swimming	Rec	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	110	0	0	VC,FW	0	0	0	Same	as	EQ	
VC, FW	80	0	0	VC, FW	40	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	30	30	0	"	"	"	
VC, FW	50	0	0	VC, FW	25	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	75	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x			VC	x	x		Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x			WQ	x			WQ	x		
FW	x	x	x	FW	x	x	x	FW	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				Hlth	x	x	x				
Hlth	x	x	x	Hlth	x	x	x	Hlth	x	x	x

AREA 13

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream				
mainstream	0*	0*	0*	
wells	3.9*	5.6*	17.1*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	0*	380*	150*	
public water supply	5.4	63.3	111.5	
industrial self-supplied water	0.86	1.24	1.84	
rural water supply	x	x	x	
irrigation, agriculture				
nonagriculture	11	14	19	
Power Plant Cooling Water	0	0	0	
Hydroelectric Power Generation				
Navigation: commercial	30	18	0	
recreation	6.9	13.8	24.6	
Water Recreation	280	390	720	
Fish and Wildlife: fishing	17	27	31	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	2100	4700	8100	
advanced	420	700	1210	
other ≠	3400	0	0	
Flood Damage Reduction: upstream				
mainstream	183	55	0	
Drainage Control				
Erosion Control	11	23	15	
Health	x	x	x	
Visual and Cultural	533	0	0	
Summation of Available Estimated Costs	7000	6400	10400	

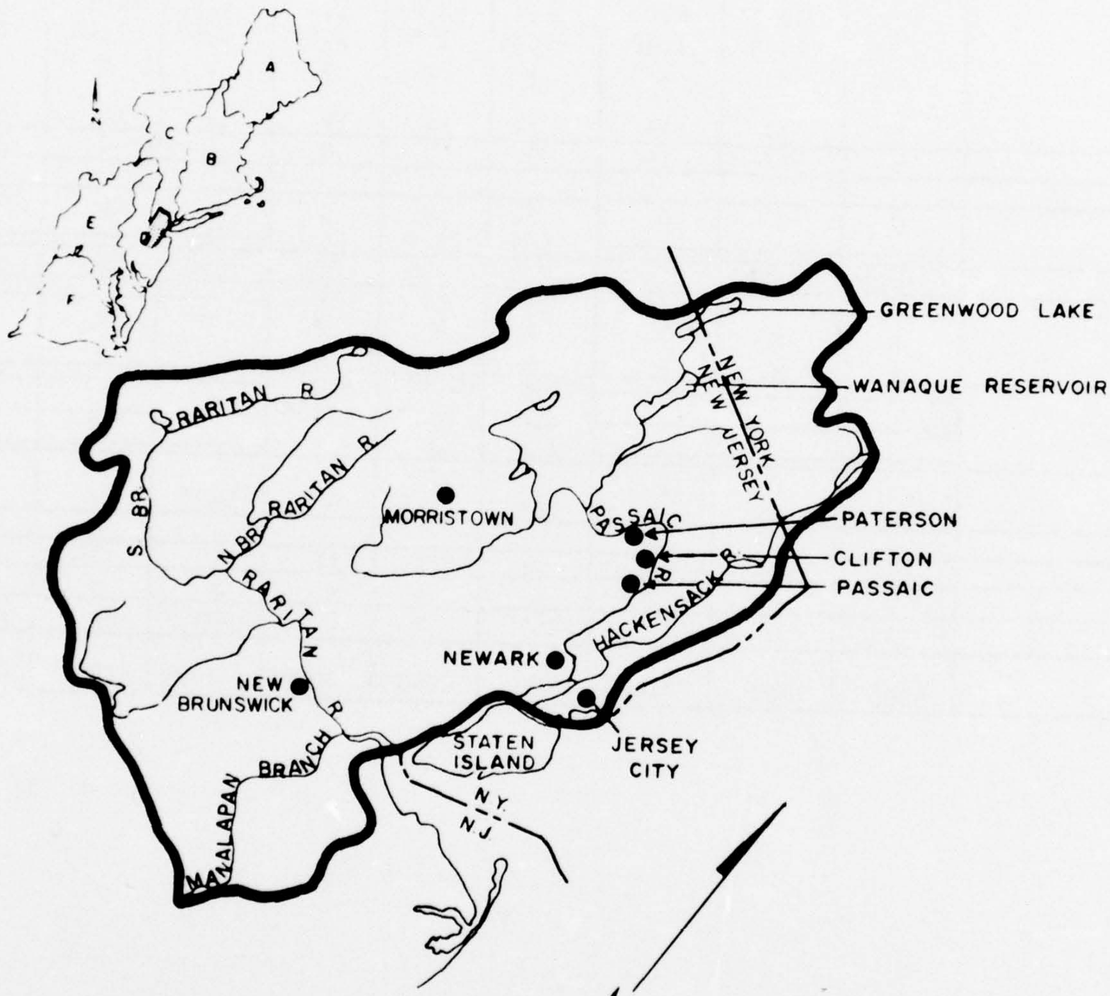
*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

AREA 13

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0 3.9	52 5.5	0 7.1	0 4.2	71 6.3	0 8.7	0 4.3	72 6.4	0 9.0
	0 9.2 0.86 x 11	120 45.5 1.09 x 14	140 69.1 1.40 x 19	0 5.4 0.86 x 11	140 63.3 1.24 x 14	170 111.5 1.84 x 19	0 6.0 0.97 x 11	140 64.1 1.40 x 14	170 113.1 2.16 x 19
	0	12	16	0	0	0	0	0	71
	0	0	0	30 6.9	18 13.8	0 24.6	30	18	0
	2470	1150	2160	280	390	720	650	550	910
	x x	x x	x x	17 x x	27 x x	31 x x	x x	x x	x x
				2100 420 3400	4700 700 0	8100 1210 0			
	183	55	0	183	55	0	183	55	0
	118	138	44	11	23	15	27	37	36
	x	x	x	x	x	x	x	x	x
	533	0	0	260	9	0	Same	as	EQ
	9300	7000	11800	6700	6200	10400	7400	6400	10700

AREA 14 NORTHERN NEW JERSEY



AREA 14

Northern New Jersey. Area 14 consists of 2,376 square miles of drainages in Newark Bay and the west side of Arthur Kill and Raritan Bay. This Area covers 157 square miles in New York State's Orange and Rockland counties and 2,219 square miles in nine northeastern New Jersey Counties. The Passaic and the Raritan are the area's two major river basins.

Nearly two-thirds of the Area consists of rolling hills with the balance in undulating hills. Over one-half of the Area consists of city landscape and the remainder consists mostly of town-farm and some forest-town landscape. The Great Swamp, a National Natural Landmark, is dedicated to migratory waterfowl management and has 3,700 acres set aside as a Wilderness Area. Two-thirds of the town-farm and forest-town landscapes have low visual quality and the rest of the Area is of medial visual quality.

Early settlers in Area 14 farmed large tracts of the rich agricultural land, and developed large livestock herds which led to the establishment of the tanning and leather industry. Agriculture gave way to industrial and urban development and by 1770 the areas closest to New York City were densely populated and extensively developed industrially.

The 1960 population of the Area was 4.1 million and is expected to increase to 8.4 million by 2020. The population is concentrated in and around the Area's three SMSA's: Newark, Jersey City and Patterson-Clifton-Passaic. Population density varied from 124 people per square mile in Hunterdon County to 13,572 per square mile in Hudson County. The Area as a whole had a density of 1,733 people per square mile.

Per capita income, although it is expected to increase substantially by 2020, will decline from its 1959 level of 23% above the national average to 18% above by 2020.

The 1960 employment of 1,649,615 is expected to increase to 3,328,000 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and transportation, communication and public utilities. Employment is expected to decrease in agriculture, forestry and fisheries; mining; food and kindred products; textile mill products; apparel and other textiles; lumber, wood products and furniture; and petroleum and coal products.

Water supplies will be insufficient to meet the Area's needs throughout the study period and significant quantities will have to be imported. The existing water resources are severly degraded in the vicinity of the many population and industrial centers.

Average annual runoff in Area 14 is approximately 2,580 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 855 m.g.d., and the corresponding seven-day minimum is about 85% of this total, or 735 m.g.d. (See Appendix C). The addition of 117 m.g.d. as an allowance for the portion of the consumptive losses reflected in streamflow records, results in an existing firm resource available for use of about 852 m.g.d., or 33% of the average runoff. This does not include any import from Area 15, Under the Supreme Court decree of 1954, the State of New Jersey is authorized to divert up to 100 m.g.d. out of the Delaware. In 1965, the maximum monthly diversion was 71 m.g.d. and the annual average was 61 m.g.d.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,496 m.g.d., or 58% of the average runoff. Potential sources which would develop the increase of 644 m.g.d., include major storage, accounting for 46% of the increase; upstream storage, 39%, and ground water development, 15%.

Possible Alternative Planning Objectives. The full range of NAR planning objectives can be considered for Area 14. The high concentration of population and industry in the downstream portion close to New York City could lend itself to a National Efficiency objective following current development trends, and following a least cost approach to the problems of the Area. Some of the downstream towns have large economic and unemployment difficulties in spite of the high per capita income level. These problems could require a Regional Development emphasis.

The poor water quality throughout the Area could require an Environmental Quality objective, particularly around undeveloped areas such as the Meadowlands and the Great Swamp. Extensive revitalization of the Area's degraded water resources could fit into both the EQ and RD objectives. The contrast between the highly developed downstream portion and the less developed upstream portions to the west could result in different objectives being recommended for different sections of the Area.

Recommended Mixed Objective. It is recommended that the mixed objective for Area 14 emphasize National Efficiency in the downstream portion closer to New York City, and Environmental Quality in the western upstream portion. This mix would allow the portion of the Area in close proximity to New York City to follow current industrial and urban development trends. The mix would then encourage environmental quality during the rural and suburban development of the upstream portions and provide some water recreation facilities. It is recommended that two portions of the Area receive special attention: the Hackensack Meadows should receive high Regional Development stimulation, and the New York portion of the Area should follow Area 12's objective mix of Regional Development with Environmental Quality.

Needs to be Satisfied. Water quality maintenance needs are the most immediate of the water management problems in northeast New Jersey. Above average growth in the industrial sectors and the projected population will require strict compliance to established water quality standards. Publicly supplied water needs are very large and grow very rapidly in Area 14 while industrial self-supplied water needs are fairly large. Both needs are dependent upon water quality maintenance which is also expected to increase moderately throughout the planning period. Rural water supply and agricultural irrigation water needs will remain relatively small throughout the planning period. The non-agricultural irrigation water needs will continually increase as golf courses and industrial landscaping become increasingly popular.

Water recreation and fish and wildlife needs grow fairly rapidly while recreational boating, commercial navigation and mainstream flood damage reduction needs grow more slowly in this Area. All of these needs except for fish and wildlife are very large. This Area combines a large and dense population with a surprising amount of open space. Visual and cultural needs as a result are not as large as would be expected. These visual and cultural needs, however, are key to achievement of the water recreation, fish and wildlife and recreational boating needs in the whole Area although they will be larger in the upstream portions. Maintenance of landscape diversity and metropolitan amenities and development of landscape quality are especially important to environmental quality. The three other environmentally related needs -- fish and wildlife, water recreation and recreational boating -- in turn, are very important to achievement of the Environmental Quality portion of the mixed objective.

There will be a large need for drainage control in the Hackensack Meadowlands as it is developed. There is an especially large need for mainstream flood damage reduction throughout the Area. Flood damage reduction is a key to the National Efficiency portion of the mixed objective because of the largely unprotected industrial and urban development that now exists and that is still growing.

Cropland drainage control, erosion control, and health needs do not increase significantly throughout the planning period. More specifically, the first two needs are closely related to maintaining landscape diversity and unique cultural sites and developing landscape quality. Health needs are related to pollution and rodent infestations.

The major power plant installations will be located primarily on the coast. Saline water needs for power plant cooling during the last two time frames will not be large. Hydroelectric power generation will have only minor increases in the early and late time periods which reflects a general lack of pumped storage sites that are both economical and compatible with environmental quality in the Area.

Devices. The most important devices are those that will serve the needs for water quality maintenance and publicly supplied water. These devices include additional mainstream storage for the 2000 planning period and upstream reservoirs for the 1980 planning period, and water treatment plants, interbasin diversions, and intake facilities in the later time frames. Withdrawal facilities will include freshwater intakes and wells throughout the study period. Water quality control facilities will feature waste treatment plants with special emphasis on advanced waste treatment, low flow augmentation, and the separation of combined sewers.

Water/Land and Land management devices can meet almost all of the navigation, erosion control, drainage control, visual and cultural, fish and wildlife and water recreation needs. The major devices for these needs include watershed management, water recreation and fish and wildlife facilities, channel improvements, land acquisition by fee simple and easement purchases, and access facilities such as overland transportation, parking areas, and trails.

Some needs, such as water recreation, fish and wildlife and visual and cultural, can not be fully satisfied by Water/Land management devices, but can be aided by multiple use of storage devices and by legal devices. This would open existing reservoirs and state and other lands to public access.

Biological devices would help fulfill fish and wildlife needs by providing opportunities for hunting, fishing, and non-consumptive wildlife demands. These devices include fish and wildlife habitat management and stocking in all time frames. Health needs require insect control, rodent control and waste treatment devices, especially if the shellfish industry of Area 13 is to be aided and if a more extensive use is to be made of the Area's lowland.

Flood damage reduction needs will require some upstream storage, but most of the requirements will be met by mainstream storage and local protection facilities. Flood plain management is opposed by the public in this Area because of the amount of management already in existence and the desire not to have it increased. Power plant cooling needs in the early time frames will be satisfied primarily by ocean intakes, so that the quality of the fresh water can be raised. Care will be taken to avoid the potential dangers of flushing excess salt and thermal discharge water into New York Bay. In the last two time periods cooling devices will be used.

Benefits. Large sociological and environmental benefits will occur from satisfying the water quality maintenance need which should result in improved landscape and recreational experiences. There will be some erosion control benefits as it will reduce non-point pollution which, in turn, will increase the effectiveness of liquid waste treatment plants. High economic benefits will result

from meeting the publicly supplied water need because the Area is water-short. Satisfying this need ensures adequate water for the growing population and, since much of the industrial water is expected to be publicly supplied, it also ensures continued industrial expansion.

Satisfaction of flood damage reduction needs will provide large multiple-use benefits to water recreation, fish and wildlife, irrigation, and visual and cultural programs, as well as provide increased safety to existing structures in the heavily urbanized flood plains.

Costs. Liquid waste treatment costs are very high because of the large amount of industry and people in the Area. Initial costs are substantial for publicly supplied water because of the large needs expected in Area 14 in relation to its relatively small available supplies.

commercial navigation development costs are large in the estuarine areas of Area 14 due, in part, to the social and environmental costs in relation to visual and cultural and water recreation needs. This relationship is a definite constraint on the level of water quality that can be obtained in this downstream portion of the Area.

Power plant cooling and flood damage reduction structures have potential costs to fish and wildlife by altering the temperature and salinity of the tidal waters. Flood damage reduction in particular may have high social costs in Area 14 because of local opposition to reservoirs, channels and flood plain management.

Costs for water recreation development will be high throughout the planning period to meet the needs of the highly urbanized centers, and to attain the mixed objective for the upper portion of the Area.

While scheduling of the project is quite uncertain, reclamation of the Hackensack Meadowlands could require large investments throughout the planning period. Although basic provisions in this portion of the Area for flood damage reduction, drainage control, and navigation would not be too costly, the development of industrial, residential, cultural, recreational and transportational uses could be extremely expensive.

Alternative Programs. If Environmental Quality were chosen to receive primary emphasis throughout Area 14, the needs of water recreation and agricultural irrigation would be much higher whereas those of publicly supplied water and commercial navigation would be lower. There would be slightly increased needs for non-agricultural irrigation and cropland drainage control. The increased needs of water recreation would be met by improving the recreational experience. This would require increased numbers of facilities producing lower densities of use at a great cost. By increasing the amount of land under irrigation the rural communities would be preserved and the visual quality landscape would be improved. The costs of meeting power generation needs would be significantly increased as increased use would be made of brackish water and less use of fresh water in the later time frames. Environmental constraints would eliminate navigation channel improvements and increase the use of diversion of cargo for commercial navigation. This would cause some of the waterborne commerce to be diverted to other Areas. Natural restoration, rather than reclamation, would be emphasized in the Hackensack Meadows. There would be increased use of all devices except river projects for upstream flood damage reduction.

Should Regional Development be emphasized the following needs would be larger -- publicly supplied and industrial self-supplied water, agricultural irrigation, commerical navigation and cropland drainage control. Streambank erosion control needs would be smaller. Publicly supplied water needs would be higher and would be met in the last time frame by diverting more water from adjacent Areas. This need would also supply more water to industry. Power plant cooling facilities would use much less saline water and increased use of brackish water. Navigation needs would be increased by the later time frame. Water recreation density would be increased by allowing increased participation in smaller areas, but at increased costs. Regional Development, as opposed to Environmental Quality, would emphasize reclamation rather than restoration in the Hackensack Meadows. Upstream flood damage reduction would have lower costs by less use of all devices.

If National Income were emphasized alone, there would be a minimum of changes from the recommended program. The visual and cultural needs would be reduced in development of metropolitan amenities and quality landscape and in maintenance of diverse landscapes. A different mix of land control devices would be used -- such as purchase leases -- to achieve the need at greatly reduced costs. Needs and costs for recreation would be greatly reduced, especially on the Raritan River. Power plant cooling needs would be met by decreased use of saline water and increased use of brackish and fresh water to eliminate the extra costs associated with the use of saline water. Upstream flood damage reduction would have lower costs by less use of all devices. All erosion control needs would be smaller to gain efficiency.

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	510	670	1230	2020
Industrial Self-Supplied Water (mgd)	280	450	470	480
Rural Water Supply (mgd)	15	19	26	21
Irrigation Water: agriculture (1000 afy)	4.2	9.4	5.7	3.4
non-agriculture (1000 afy)	8	17	28	43
Power Plant Cooling: withdrawal, saline (cfs)	5000	4800	6400	10000
brackish (cfs)	0	0	0	1500
fresh (cfs)	0	0	14	59
consumption, brackish (cfs)	0	0	0	14
fresh (cfs)	0	0	7	33
Hydroelectric Power Generation (mw)	6	130	130	300
Navigation: commercial (m. tons annually)	140	170	230	360
recreational boating (1000 boats)	140	190	270	430
Water Recreation: visitor days (m.)	x	80	130	230
stream or river (miles)	x	170	260	350
water surface (1000 acres)	x	48	70	99
beach (acres)	x	490	730	1170
pool (m. sq. ft.)	x	10	14	23
land facilities (1000 acres)	x	27	39	61
Fish & Wildlife: sport fishing man-days (m.)	1.9	2.2	2.6	3.1
surface area, lake (acres)	x	0	1200	2800
stream (acres)	x	300	900	1600
access, fresh (acres)	x	30	100	180
salt (acres)				
anadromous (acres)	x	2	3	4
piers (1000 feet)				
hunting man-days (m.)	1.5	1.6	1.9	2.3
access (1000 sq. mi.)	x	0.20	0.45	0.75
nature study man-days (m.)	4.5	5.0	6.0	7.3
access (1000 acres)	x	24	66	114
Water Quality Maint.: non-industrial (m. PEs)	4.1	5.0	6.1	7.3
industrial (m. PEs)	12	26	52	105
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	1.1	1.6	2.9	5.4
mainstream (m.$)	19	29	55	105
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	19	25	40	44
forest land (1000 acres)				
wet land (1000 acres)	x	x		
Erosion Control: agriculture (1000 acres)	120	150	170	170
urban (1000 acres)	490	750	980	1160
stream bank (mi.)	x	37	111	185
coastal shoreline (mi.)				
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)				
unique shoreline (mi.)				
high quality (sq.mi.)				
diversity (sq.mi.)	x	30	60	90
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	130	260	390
diversity (sq.mi.)				
metro. amenities (mi.)	x	2	2	2
" " (sq.mi.)	x	60	60	60

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	640	1100	1680	670	1230	2020	680	1270	2130
	450	460	480	450	470	480	460	480	490
				19	26	21			
	13.6	19.1	20.3	9.4	5.7	3.4	13.6	19.1	16.8
	18	29	43	17	28	43	17	29	43
	4900	5400	8000	4900	4400	7400	4900	3400	2800
	0	1000	2500	0	2000	5000	0	2000	4300
	0	0	21	0	1000	1000	0	28	49
	0	8	22	0	16	43	0	16	93
	0	0	10	0	8	28	0	13	23
				130	130	300			
	150	210	280	170	230	360	170	250	400
				190	270	430			
	80	120	230	70	110	220	80	130	230
	350	530	710	120	180	230	170	260	350
	90	133	183	25	37	52	48	70	99
	1070	1580	2630	400	580	980	490	730	1170
	18	27	45	8	11	19	10	14	23
	74	106	170	14	19	31	27	39	61
				2.2	2.6	3.1			
				0	1200	2800			
				300	900	1600			
				30	100	180			
				2	3	4			
				1.6	1.9	2.3			
				0.20	0.45	0.75			
				5.0	6.0	7.3			
				24	66	114			
				5.0	6.1	7.3			
				26	52	105			
				1.6	2.9	5.4			
				29	55	105			
	29	48	51	25	40	44	29	48	51
				x					
	150	170	170	140	150	150	150	170	170
	760	980	1160	600	780	920	750	980	1160
	37	111	185	7	25	43	18	55	92
	x	x	x	x	x	x	x	x	x
	30	60	90	15	30	45	Same	as EQ	
	130	260	390	65	130	195	Same	as EQ	
	2	2	2	2	2	2	Same	as EQ	
	60	60	60	30	60	60	Same	as EQ	

AREA 14

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	137.8*	0.4*	x
mainstream (1000 af)	FW,Rec,VC,WQ	x	108*	x
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	140	190	790
brackish (mgd)	Ind.	370	520	740
estuarine (mgd)	Pow		x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		9*	119*	16*
Conveyance Facilities				
interbasin diversions, into (mgd)		35*	300*	530*
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow		x	x
chemical/biological				
potable water treat plants (mgd)	PS	27	363	860
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	28	52	101
advanced (95%) (m. PE removed)	WQ,VC	1.6	2.9	5.6
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x		
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x		
Pumped Storage	HPG	x		x
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC,Rec	6	13	16
mainstream (1000 acres)	FDR,VC,Rec	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	14	15	1
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	51	158	116
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline				
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig

$\nmid$ Also includes the following purposes: VC,Rec,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	7.2	2.5	0.5	Irrig †	2.3	x	x	Irrig †	4.2	2.5	x
PS,WQ †	x	33	67	PS,WQ †	x	75	220	PS,WQ †	x	75	280
Pow**	130	170	580	Pow**	140	190	790	Pow**	150	200	890
Ind	370	440	530	Ind	370	520	740	Ind	400	600	900
Pow		x	x	Pow		x	x	Pow		x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	101	143	13	Rur**	103	171	13	Rur**	109	183	13
PS	0	90	480	PS	0	90	670	PS	0	90	760
Pow			x	Pow			x	Pow		x	x
PS	22	234	655	PS	27	363	860	PS	28	370	961
				WQ,VC	28	52	101				
				WQ,VC	1.6	2.9	5.6				
VC	x										
WQ,VC	x			WQ,VC	x			WQ,VC	x		
WQ,VC	x			WQ,VC	x			WQ,VC	x		
				HPG	x		x				
FDR,VC	9	23	28	FDR,VC	3	2	5	FDR,VC	3	2	4
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	17	14	0	FDR	10	15	0	FDR	10	15	2
FDR,Drn,VC	92	184	184	FDR,Drn,VC	10	132	x	FDR,Drn,VC	10	132	48
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x		Nav	x	x	
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 14

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	205	145	145
fee simple purchase (buying) (mi.)	VC, FW	2	0	0
purchase lease (sq.mi.)	VC,FW	0	0	0
easements (sq.mi.)	VC, FW	15	15	15
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC, FW	x		
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)				
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW,WQ	x	x	x
Insect Control	Hlth	x	x	x
II. Research				
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions	FW,VC,Rec	x	x	x
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	12	40	9
Mainstream Flood Control Storage(1000af)	FDR	0	260	0
Ground Water Management Program	PS	x	x	x
Water Front Renewal	Rec	x	x	x
Flood Insurance	FDR	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	205	145	145	VC, FW	30	30	0	Same	as	EQ	
VC, FW	2	0	0	VC, FW	2	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	65	65	65	"	"	"	
VC, FW	15	15	15	VC, FW	15	15	15	"	"	"	
VC, FW	x			VC, FW	x			"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
←				FW	x	x	x				→
VC	x	x	x	VC	x	x	x	Same	as	EQ	
←				FW	x	x	x				→
←				FW	x	x	x				→
←				FW	x	x	x				→
←				FW	x	x	x				→
←				FW	x	x	x				→
←				Hlth	x	x	x				→
←				FW	x	x	x				→
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	22	60	0	FDR	2	20	0	FDR	2	20	17
FDR	0	260	0	FDR	0	260	0	FDR	0	260	0

AREA 14

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	30.8*	0.2*	0*	
mainstream	0*	54*	0*	
wells	4.6*	7.6*	1.2*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	9.7*	89.2*	416.5*	
public water supply	18	88	146	
industrial self-supplied water	2.59	2.80	3.99	
rural water supply	x	x	x	
irrigation, agriculture	0.34	0	0	
nonagriculture	7.9	9.1	11.5	
Power Plant Cooling Water	0	5.5	7	
Hydroelectric Power Generation	x		x	
Navigation: commercial	99	0	0	
recreation	8.7	10.3	14.3	
Water Recreation	430	360	610	
Fish and Wildlife: fishing	0.49	0.98	1.12	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	2200	3900	7700	
advanced	320	600	1200	
other ≠	910	0	0	
Flood Damage Reduction: upstream	4.0	7.8	0.8	
mainstream	120	430	0	
Drainage Control	0.48	1.20	0.32	
Erosion Control	44	38	30	
Health	x	x	x	
Visual and Cultural	125	70	70	
Summation of Available Estimated Costs	4300	5700	10200	

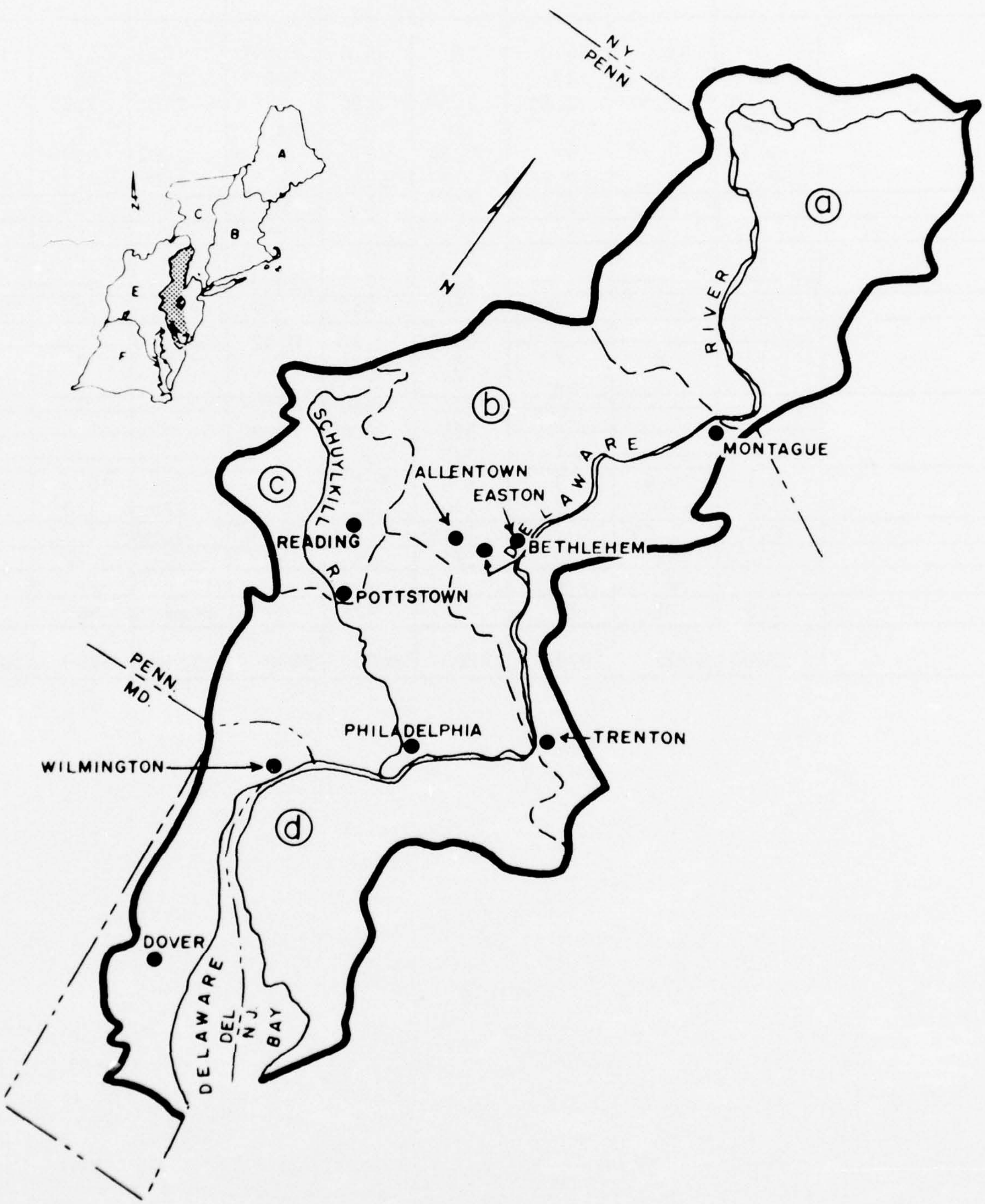
*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

AREA 14

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0.2	0.2	0	0.06	0	0	0.2	0.2	0
	0	21	41	0	122	76	0	122	231
	6.8	9.2	2.4	6.8	10.9	2.5	7.2	11.6	2.5
	0	35.6	66.0	0	35.6	108.0	0	35.6	144.0
	16	64	123	18	88	146	18	89	154
	2.58	2.39	2.86	2.59	2.80	3.99	2.81	3.25	4.87
	x	x	x	x	x	x	x	x	x
	1.32	0.98	0	0.34	0	0	1.32	0.98	0
	8.2	9.1	11.2	7.9	9.1	11.5	8.0	9.2	11.4
	0	26	122	0	0	0	0	14	47
	x		x	x		x	x		x
	0	0	0	99	0	0	99	0	0
				8.7	10.3	14.3			
	1230	740	1360	240	260	480	430	360	610
				0.49	0.98	0.12			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				2200	3900	7700			
				320	600	1200			
				910	0	0			
	6.5	10.6	0	1.4	5.1	0	1.4	5.1	1.6
	120	430	0	120	430	0	120	430	0
	0.80	1.52	0.24	0.48	1.20	0.32	0.80	1.52	0.24
	44	38	30	18	29	23	43	37	29
	x	x	x	x	x	x	x	x	x
	125	70	70	76	48	34	Same	as	EQ
	13200	6000	10700	12200	5600	9800	12500	5700	10200

AREA 15 DELAWARE RIVER BASIN



AREA 15

Delaware River Basin. Area 15 consists of the Delaware River Basin which drains portions of New York, New Jersey, Pennsylvania and Delaware as well as a small portion of Maryland. The Area has been divided into four sub-areas as follows: sub-area a is the Delaware River above Montague, N. J.; b is the Delaware River above Trenton, N.J.; c is the Schuylkill River above Pottstown, Pa., and d is the remainder of the basin. There are 12,765 square miles in the Area.

There is great diversity of land form as the basin contains all types of landscape. The most extensive types of landscape are rolling-hills and undulating land. Forest-town and town-farm comprise the major landscape patterns over fifty percent of the Area. The other patterns are city, farm and farm-forest. The over-all visual landscape quality of the river basin is high since it possesses such diversity in land form and in land pattern. Presently, Philadelphia has the second largest port on the East coast.

The population of the Area in 1960 was 6.4 million with a density of 531 people per square mile. The greatest concentration of people is in the Philadelphia Area, while the density of people in the sub-areas range from 993 per square mile in sub-area d, to 34 people per square mile in sub-area a. The projected population for 2020 is 11.9 million.

Per capita income was 11.8% above the national average in 1959, but is projected to decline to 2.5% above the national average by 2020.

The 1960 employment of 2.5 million is expected to increase to 4.8 million by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; machinery; and transportation, communication and public utilities. Employment is expected to decrease in agriculture, forestry and fisheries, mining; food and kindred products; textile mill products; apparel and other textiles; and petroleum and coal products.

Water is generally abundant in the Area although not always in a usable form due to the amount of pollution. Pollution from acid mine drainage exists in the upper Lehigh and Schuylkill Rivers. Some efforts for controlling acid mine drainage are now being made in the Pennsylvania portion of the Area. These efforts include new treatment plants for acid streams and elimination of land scars created by past mining practices. Municipal and industrial wastes degrade the water quality in the vicinity of population and industrial centers, particularly from Trenton to Delaware Bay.

Supreme Court decrees in 1931 and 1954 have prescribed compensating releases from reservoirs and other conditions for diversions out of the basin. Reservoirs under the decree include: Neversink, Cannonsville and Pepacton. Recently, water resource development has been guided by the recommendations and project authorizations resulting from the Type II comprehensive study completed in 1960. The study is revised yearly and

carried out under the guidance of the Delaware River Basin Commission.

Average annual runoff in Area 15 is approximately 13,200 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,800 m.g.d., and the corresponding seven-day minimum is about 65% of this total, or 1,800 m.g.d. (See Appendix C). With the Tocks Island and Beltzville Lakes in operation, and a minimum flow at Montague, N.J., of 1,130 m.g.d., the latter flow would be about 4,075 m.g.d. The addition of 160 m.g.d. for those consumptive losses not included, and 605 m.g.d. developed for export to Areas 12 and 14, results in firm resource available for use of 4,840 m.g.d., or 37% of the average runoff. This does not clude about 25 m.g.d. which can be imported from Area 17.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 7,562 m.g.d., or 57% of the average runoff. Potential sources which would develop the increase of 2,722 m.g.d., include major storage, accounting for 44% of the increase; upstream storage, 33%, and ground water development, 23%.

Possible Alternative Planning Objectives. All of the NAR objectives can be emphasized in the Delaware River Basin. This Area has a large variety of landscapes, industries, water uses, population densities and levels of income. Because of this diversity, it is unlikely that one emphasized objective or even the same mix of emphasized objectives can be evenly applied over the entire Area.

National Efficiency can be easily emphasized in the more industrialized and high populated sections of Area 15, which seem to be fairly prosperous, especially along the middle portions of the Delaware River. The Delaware River is located so centrally to most economic activities and resources of the Area that investments in water resources can be of more advantage to a Regional Development emphasis than is typical of such investments. Similarly, landscape and land use diversity of the Area can contribute a great deal to the recreational activities and visual assets for the large nearby population centers.

Recommended Mixed Objective. All three NAR objectives are emphasized in one more more locations of this Area because of the variety of resources and activities.

The New York portion of the Area should equally emphasize Regional Development and Environmental Quality. The rest of sub-area a and the Pennsylvania portions of sub-area b should emphasize Regional Development with some attention given to Environmental Quality. This emphasized mixed objective, similar to that of Area 12, will allow the sub-area's water resources management program to support those parts of the economy which can aid the poor and the unemployed portions of the population. Paying some

attention to Environmental Quality will aid in protecting and enhancing the sub-areas' considerable landscape and recreational resources, such as the Catskill Mountains and upper Delaware River, which serve large nearby metropolitan populations. The New Jersey portions of sub-area b should emphasize Environmental Quality alone since the recreational resources are in high demand and form the major part of this sub-area's economy.

Sub-area c should emphasize Environmental Quality with some Regional Development. This whole sub-area needs large amounts of aid in solving its acid mine drainage problems which are identical to the problems of the adjacent eastern portion of sub-area d in Area 17. The unemployed in the sub-area need the help of Regional Development benefits.

Sub-area d has four separate mixed objectives. The Pennsylvania portion of the sub-area is well enough off economically to have National Efficiency emphasized but needs some attention to Environmental Quality to preserve it landscape and recreation resources that are in high demand.

The New Jersey portions of sub-area d should emphasize Regional Development north of the Delaware Memorial Bridge because of the aid that some economic sectors require in that part of the sub-area. South of the Bridge an equal mix of National Efficiency and Environmental Quality should be emphasized. This portion of the sub-area has an adequate economy but needs some aid in preserving its unique landscapes, forests, marshes and shorelines. Delaware's portion of sub-area d should primarily emphasize Environmental Quality. Delaware is expected to be able to easily keep its fairly high level of income but needs to push improvements in its environmental resources because of the density of its urban settlements.

Needs to be Satisfied. The water quality maintenance need is the largest and the most difficult to meet of the water resource needs in Area 15. The mixed objective calls for degrees of water quality that would enhance a vigorous growth in industry, recreational facilities, and preservation of the environment. Of all the rapidly growing needs in this Area the improvement and continuity of water quality maintenance is the most important and is key to the fulfillment of other needs in the Area. Although adequate resources exist, the withdrawal needs within the Area, as well as possible water diversions to nearby Areas, may be sharply curtailed if water quality standards are not satisfied.

Water recreation, visual and cultural, and fish and wildlife needs will be large and important in all sub-areas for the early and mid-time periods. Maintenance of landscape diversity, and agricultural lands, water surface area, and access to fishing, hunting and nature study, stream and river shorelines are among the greatest of these needs. Maintenance of shoreline and marshland and developing urban amenities also rate high for all time frames. The Area serves

as a substantial source of activities connected with high environmental quality, water fowl and commercial and sport fisheries because its resources serve as the many large nearby urban regions. The effective and judicious use of these natural resources will add to the income of the Area's population.

Publicly supplied water, industrial self-supplied water, and power plant cooling are expected to have very large water withdrawal needs for all-time periods. The growth rates of these needs except for publicly supplied water, are also high. Rural water supply needs are very large and grow fairly rapidly in this Area. Consumptive uses of water will be the largest problem among the withdrawal type needs. Hydroelectric power generation needs are large to supply peak power requirements of the region's market. This is a site oriented need and it will have a moderate growth rate in subareas a,b, and c.

Flood damage reduction needs are important due to the existing and expected levels of development in the upstream, mainstream and coastal flood plains. Irrigation needs will be large throughout the planning period but those for agriculture will actually decrease in the last time phase whereas non-agricultural needs will increase fairly rapidly in all time frames. The varying growth rates of these needs are due to the anticipated slow growth rate of irrigated specialty crops in the Area and the large growth rates of institutional and recreational uses of irrigation water.

Navigation needs are large in this Area. Commercial navigation needs grow rapidly during the first planning period and recreational boating needs steadily increase. Commercial navigation needs will be important in meeting the large industrial transportation needs of the Area. The Delaware River will be critical in meeting all types of transportation and water recreation needs of the Area because of its central location. Recreational boating will be key to meeting these water recreation needs.

The needs for erosion and drainage control have fairly steady growth rates during the planning period. Agricultural, urban, coastal and streambank erosion control needs are large in this Area, although not of large importance to the mixed objective. Health needs include vector and pollution control.

Devices. Upgrading and preserving the quality of the Area's water is paramount so that industrial growth, expanding population, and increasing recreational activities can be supported. This need for water quality maintenance requires many different types of quality control facilities in Area 15 for all time frames. The important and key devices will include cooling towers, wells, fresh water intakes, waste treatment plants, nutrient control, and the separation of combined sewers. These devices, along with storage, research and

power plant cooling devices, will enable those needs to be met that require water withdrawals and out-of-basin transfers throughout the planning period. Storage will be an important device for these needs. Decisions on any basin transfers must go through a review procedure of the Delaware River Basin Commission and the transfers must meet certain criteria including no interference with the U.S. Supreme Court Decisions.

The bulk of the self-supplied industrial water need will be met by fresh and brackish intakes and re-use. Acid mine drainage pollution requires new investments for treatment of operating mine sources. The use of wells for rural water supply needs is expected to decline as the central water systems expand. Research is necessary for better water quality maintenance devices and should include examining of beneficially using waste heat from power plant cooling devices.

Water/Land devices can meet the drainage control, erosion control and navigation needs and can partially meet flood damage reduction, water recreation, visual and cultural and fish and wildlife needs. Many types of land use problems will exist in the Area, however, and research and planning will be essential parts of the solution. Flood damage reduction needs will require upstream storage since flood plain management will have lower than average effectiveness (about 35 percent). This is due primarily to public reactions against land-use controls and to the existing and planned development of the flood plains.

Water recreation and fish and wildlife needs will require new water surfaces and access devices since most of the existing lakes and reservoirs have been fully developed and parking areas and foot trails are overburdened. The portion of the Delaware River between Hancock, New York, and Matamoras, Pennsylvania, can be established as part of the national scenic and wild rivers system. This action will hlep fulfill water recreation, visual and cultural and fish and wildlife needs by supplying scarce wilderness experiences. This system is endorsed by the Delaware River Basin Commission.

Power plant cooling needs will require cooling towers and brackish, fresh, estuarine, and saline intakes. These devices, with pumped storage projects for peaking power and some non-condensing facilities for base load operations, will permit the development of the required energy supply for all-time periods without undue stress on environmental quality. Devices for agricultural irrigation include storage facilities, river intakes, and wells to satisfy the need and retain, the competitiveness of agriculture in the Area. The use of waste effluent from sewage disposal plants can serve as a supplement to meet the projected heavy need for non-agricultural irrigation water in all time periods of the program.

Some of the visual and cultural and fish and wildlife needs will be met by the limited amount of easements, fee simple purchases and zoning and/or tax incentive subsidies in all time periods, and by purchase leases in the early time frame. These devices will allow for the development of metropolitan amenities and the maintenance of landscape diversity and of unique natural and shoreline landscapes before costs for such actions escalate and become prohibitive or pressures for development become too great. Fish and wildlife needs require the use of almost all types of Biological devices. Adequate flow releases and water quality maintenance in the Delaware River will be important to achievement of commercial and recreational fishery needs. Anadromous fish resources and the oyster industry are especially amenable to such devices.

Benefits. Simultaneously emphasizing EQ, NE, and RD objectives in different parts of the Area will result in large benefits from the suggested program. Large social, environmental and economic benefits will result from the satisfaction of water quality maintenance needs since water quality is so central to being able to attain public and industrial water supply, water recreation, fish and wildlife, visual and cultural and health needs. Large economic benefits will result from the satisfaction of commercial navigation, power plant cooling and industrial self-supplied water needs. Any future uses that are found for waste heat will also provide large benefits.

The satisfaction of visual and cultural, fish and wildlife and water recreation needs will bring large economic benefits to subareas a and b since they serve as sources of recreation for sub-area d and Area 14. There will also be benefits from increases in the commercial fishing industry.

Satisfaction of irrigation needs will result in economic benefits from maintenance of the Area's agricultural economy as well as in non-monetary benefits to visual and cultural needs from the maintenance of landscape variety.

Installation of devices to satisfy public water supply needs will also provide benefits outside Area 15 by making water available for diversion to nearby Areas which have water deficiencies.

Costs. Initial capital costs to satisfy water quality maintenance, and visual and cultural needs are much larger than those to satisfy other needs because of the high degree of industrialization and urbanization of Area 15. Visual and cultural costs are for land purchases and easements to control landscape quality and are largest in the first planning period. These devices are particularly costly in the areas which are being rapidly urbanized and where timing is critical to ensure success. Water quality maintenance costs will be very large in this Area because of the very large quantity of all types of waste: agricultural, industrial and municipal. Achievement

of water quality standards will increase the costs for fulfillment of power plant cooling and commercial navigation needs because of the necessity of controlling thermal pollution and commercial navigation spillages, respectively.

Navigation and water recreation have the next highest monetary costs. These needs tend to interact in such a manner that there are increased social costs as industrial and recreational activities compete in the lower 100 miles of the Delaware River. Navigation development may result in increased monetary costs for publicly supplied water as shipping spills affect water quality and as channel modifications may affect the location of the salt front and the ground water table. Navigation monetary costs are significantly greater in the first two planning periods to insure the development of transportation which will allow the industries of Area 15 to operate competitively, nationally and internationally, during the remaining period.

Power plant cooling costs rise to moderately high levels in the latter time periods. The attention to environmental quality throughout most of the Area results in significant costs in siting, devices and non-condensing facilities necessary to reduce environmental conflicts while meeting higher power needs.

Alternative Programs. If Environmental Quality were chosen to be emphasized throughout Area 15, there would be a large increase in irrigation needs and costs. Meeting irrigation needs would help insure the preservation of the Area's farms and thus the Area;s landscape diversity. Contrarily, publicly supplied and industrial self-supplied water needs would drop slightly. There would be a decrease in saline and fresh water withdrawal and an increase in brackish withdrawal. This change, at greater costs, would help keep down thermal pollution providing additional benefits to fish and wildlife visual and cultural and water recreation needs. Commercial navigation needs would decrease and no channel improvements would be made. Water recreation visitor day needs would decrease and all other recreation needs would increase as fewer visitors would be accomodated at higher costs to attain high quality experiences. More white water conoeing and surface waters for recreation would be made available. Increased use would be made of all devices for upstream flood damage reduction at increased costs to aid environmental quality. Cropland drainage control needs and costs would rise. Visual and cultural needs would still be high throughout the Area and only the costs would rise as more secure devices for land control would be used.

Emphasizing National Income would decrease the desirability of using expensive devices for fulfilling power plant cooling needs and no non-condenser facilities would be used. This would allow cheaper production of electricity for the Area's industry. There would be more brackish and fresh water withdrawals in the last two time periods for industrial use. Industrial self-supplied water needs would decrease. Water recreation needs and costs would be reduced as less attention

would be given to high quality experiences and to recreation as an industry in the Area. Erosion control needs would be reduced as less attention would be given to the effects of erosion upon the environment retaining those portions of the need that would make for a more efficient agricultural industry. Visual and cultural needs would be reduced. This would retain only those portions of these needs that would have to be preserved now or lost.

Regional Development could be emphasized more in Area 15. Irrigation needs would be increased by subsidy because of its ability to add to the Area's income as well as add to the visual and cultural landscape diversity and, thus, to the recreation industry. Power plant cooling needs would be raised in the last two planning periods and no use would be made of non-condensing facilities to lower costs. Commercial navigation needs would be raised slightly. Upstream flood damage reduction needs would be spread out through the three planning periods. Larger drainage control needs would be met to make agriculture and forestry more efficient. Streambank and shoreline erosion control needs would be smaller. Visual and cultural costs should be raised to more securely retain the Area's landscapes. More secure land controls would be used for visual and cultural needs at much higher costs.

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	800	1000	1400	2000
Industrial Self-Supplied Water (mgd)	1000	2000	4100	7600
Rural Water Supply (mgd)	50	77	112	104
Irrigation Water: agriculture (1000 afy)	40	120	140	110
non-agriculture (1000 afy)	16	42	74	119
Power Plant Cooling: withdrawal, saline (cfs)	0	2900	11900	18300
brackish (cfs)	3900	2900	5200	11000
fresh (cfs)	2700	2600	3000	3400
consumption, brackish (cfs)	37	30	43	94
fresh (cfs)	30	110	260	490
Hydroelectric Power Generation (mw)	400	1800	4200	7500
Navigation: commercial (m.tons annually)	120	180	240	390
recreational boating (1000 boats)	170	220	320	540
Water Recreation: visitor days (m.)	x	120	190	330
stream or river (miles)	x	310	460	610
water surface (1000 acres)	x	80	110	160
beach (acres)	x	740	1080	1590
pool (m. sq. ft.)	x	15	21	31
land facilities (1000 acres)	x	51	57	83
Fish & Wildlife: sport fishing man-days (m.)	9	11	14	17
surface area, lake (acres)	x	3000	16000	30000
stream (acres)	x	0	1400	3400
access, fresh (acres)	x	260	640	1090
salt (acres)	x	120	300	510
anadromous (acres)	x	14	30	50
piers (1000 feet)	x	3.4	8.5	14.6
hunting man-days (m.)	7.3	8.4	10.5	13.0
access (1000 sq. mi.)	x	0.8	2.3	3.9
nature study man-days (m.)	9	11	13	17
access (1000 acres)	x	28	73	130
Water Quality Maint.: non-industrial (m. PEs)	6	8	10	13
industrial (m. PEs)	12.	32	81	188
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	4.3	6.2	10.3	18.5
mainstream (m.$)	10	16	30	62
tidal & hurricane (m.$)	2.2	3.4	6.6	13.7
Drainage Control: cropland (1000 acres)	110	140	230	250
forest land (1000 acres)	0	0	6	25
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	1200	1600	1900	2000
urban (1000 acres)	1000	1400	2000	2600
stream bank (mi.)	x	70	200	340
coastal shoreline (mi.)	x	42	87	93
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	160	160	160	160
unique shoreline (mi.)	x	16	16	16
high quality (sq.mi.)				
diversity (sq.mi.)	x	1200	2400	3600
agriculture (sq.mi.)	x	800	800	800
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)		180	180	180

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	1000	1300	1700	1000	1400	2000	1000	1400	2100
	1900	3600	6100	1900	3800	6800	2000	4000	7600
				77	112	104			
	230	500	570	120	140	110	230	500	470
	50	81	119	42	74	119	44	78	119
	2900	6200	6700	2900	11200	20000	2900	5200	7300
	2900	10000	17500	2900	7000	14500	2900	9000	18400
	2600	2100	2000	2600	6700	8900	2600	5500	8500
	30	135	253	30	58	126	30	74	207
	110	190	330	110	260	510	110	310	510
				1800	4200	7500			
	140	200	300	180	240	390	200	270	440
				220	320	540			
	120	190	330	100	160	300	120	190	330
	630	930	1230	210	310	410	310	460	610
	150	220	310	40	60	80	80	110	170
	1620	2360	3600	600	870	1450	740	1080	1590
	28	41	62	12	17	28	15	21	31
	147	161	242	21	30	43	51	57	83
				11	14	17			
				3000	16000	30000			
				0	1400	3400			
				260	640	1090			
				120	300	510			
				14	30	50			
				3.4	8.5	14.6			
				8.4	10.5	13.0			
				0.8	2.3	3.9			
				11	13	17			
				28	73	130			
				8	10	13			
				32	81	188			
				6.2	10.3	18.5			
				16	30	62			
				3.4	6.6	13.7			
	160	270	290	140	230	250	160	270	290
	0	6	25	0	6	25	6	25	82
	1600	1900	2000	1500	1700	1700	1600	1900	2000
	1400	2000	2600	1100	1300	1700	1400	2000	2600
	70	200	340	10	50	80	30	100	170
	42	87	93	1	3	5	2	5	8
	x	x	x	x	x	x	x	x	x
	160	160	160	160	160	160	Same	as EQ	
	16	16	16	8	8	8	Same	as EQ	
	1200	2400	3600	800	1600	2400	Same	as EQ	
	800	800	800	800	800	800	Same	as EQ	
	180	180	180	180	180	180	Same	as EQ	

AREA 15

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	40*	60*	780*
mainstream (1000 af)	FW,Rec,VC,WQ	4*	19*	173*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	800	1700	3200
brackish (mgd)	Ind	800	1400	2300
estuarine (mgd)	Pow	x	x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		50*	40*	210*
Conveyance Facilities				
interbasin diversions, into (mgd)		37*	0*	0*
out of (mgd)		35*	300*	0*
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	87	247	247
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	36	83	181
advanced (95%) (m. PE removed)	WQ,VC	2.0	4.6	10.1
effluent irrigation	Irrig	x	x	x
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control	WQ,VC	x	x	x
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG	x	x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC,FW	81	x	22
mainstream (1000 acres)	FDR,VC,FW	x	x	x
Local Flood Protection				
ocean (projects)	FDR	1	0	0
river (projects)	FDR	14	27	0
flood control channels (mi.)	FDR	1	379	0
Watershed Management (1000 acres)	FDR,Drn,VC	29	542	x
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig
ƒ Also includes the following purposes: VC,Rec,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	120	180	40	Irrig †	50	10	x	Irrig †	120	180	x
PS,WQ †	34	42	10	PS,WQ †	43	43	14	PS,WQ †	45	43	15
Pow**	700	1300	1900	Pow**	700	1500	2700	Pow**	800	1700	3300
Ind	700	1200	1600	Ind	700	1300	2000	Ind	800	1400	2300
Pow		x	x	Pow		x	x	Pow		x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	390	660	780	Rur**	360	650	630	Rur**	410	780	610
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
PS	68	192	283	PS	87	247	247	PS	91	250	413
				WQ,VC	36	83	181				
				WQ,VC	2.0	4.6	10.1				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
				HPG	x	x	x				
FDR,VC	248	384	250	FDR,VC	81	x	22	FDR,VC	74	x	27
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	1	0	0	FDR	1	0	0	FDR	1	0	0
FDR	26	50	45	FDR	14	27	0	FDR	20	21	6
FDR	380	0	0	FDR	1	379	0	FDR	91	289	1
FDR,Drn,VC	536	1072	1072	FDR,Drn,VC	29	542	x	FDR,Drn,VC	155	416	126
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x		Nav	x	x	
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	400	400	400
fee simple purchase (buying) (mi.)	VC,FW	16	0	0
purchase lease (sq.mi.)	VC, FW	400	0	0
easements (sq.mi.)	VC, FW	600	400	400
deed restrictions (sq.mi.)	VC, FW	x	x	x
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW	780	400	400
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)	Ind		x	x
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	4	106	0
Mainstream Flood Control Storage (1000af)	FDR	47	58	0
Flood Insurance	FDR	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	780	600	600	VC,FW	180	0	0	Same	as	EQ	
VC,FW	16	0	0	VC,FW	8	0	0	"	"	"	
VC, FW	800	0	0	VC, FW	580	0	0	"	"	"	
VC, FW	600	600	600	VC, FW	500	500	500	"	"	"	
VC,FW	0	0	0	VC,FW	700	300	300	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
Pow		x	x								
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	110	180	179	FDR	4	106	0	FDR	19	29	24
FDR	47	58	0	FDR	47	58	0	FDR	47	58	0

AREA 15

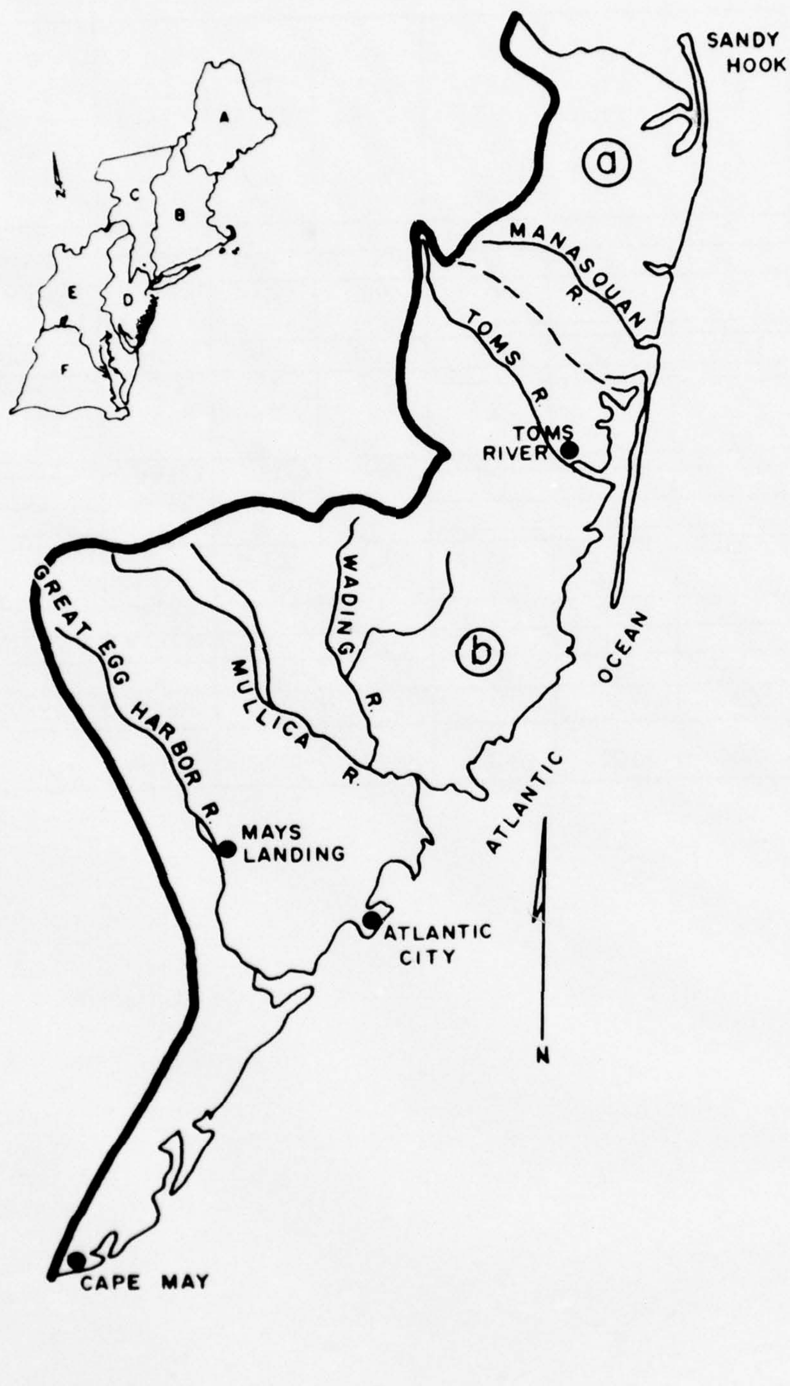
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE 1980	2000	2020	
Water Development Costs:				
storage, upstream	12.4*	30.0*	204.2*	
mainstream	3.3*	16.3*	107.4*	
wells	14.7*	12.4*	15.1*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	9.7*	0*	0*	
public water supply	78	172	231	
industrial self-supplied water	8.05	16.15	29.13	
rural water supply	x	x	x	
irrigation, agriculture	9.5	6.0	0	
nonagriculture	22	23	31	
Power Plant Cooling Water	0	110	232	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial	340	450	0	
recreation	3.0	5.2	9.5	
Water Recreation	300	410	630	
Fish and Wildlife: fishing	4.2	6.0	7.2	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	860	6160	13680	
advanced	60	940	1710	
other ≠	3.4	0	0	
Flood Damage Reduction: upstream	1.6	23.7	0	
mainstream	23	17	0	
Drainage Control	2.6	7.1	2.7	
Erosion Control	125	146	88	
Health	x	x	x	
Visual and Cultural	750	280	280	
Summation of Available Estimated Costs	2600	8800	17300	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	8.2	14.4	2.5	2.2	1.4	0	8.2	14.4	0
	37.9	21.0	11.5	47.9	23.1	16.8	50.3	23.1	16.8
	24.6	45.9	54.9	21.2	43.7	48.2	25.5	54.3	43.4
	0	0	0	0	0	0	0	0	0
	63	136	165	78	172	231	81	174	233
	7.64	13.07	18.56	7.64	14.60	24.34	8.05	16.15	29.13
	x	x	x	x	x	x	x	x	x
	35.8	62.3	10.9	9.5	6.0	0	35.8	62.3	0
	25	23	29	22	23	31	23	24	30
	0	230	816	0	0	0	0	84	285
	x	x	x	x	x	x	x	x	x
	0	0	0	340	450	0	340	450	0
	←			3.0	5.2	9.5			→
	1320	920	1500	100	290	410	300	410	630
	←			4.2	6.0	7.2			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			860	6160	13680			→
	←			60	940	1710			→
	←			3.4	0	0			→
	25.3	48.8	48.8	1.6	23.7	0	3.1	22.2	5.6
	23	17	0	23	17	0	23	17	0
	4.3	8.9	2.0	2.6	7.1	2.7	4.5	9.4	3.5
	125	146	88	24	50	58	64	82	81
	x	x	x	x	x	x	x	x	x
	1180	350	350	540	130	130	Same	as	EQ
	3800	9100	18500	2200	8400	16400	3100	8900	17100

AREA 16 COASTAL NEW JERSEY



AREA 16

Coastal New Jersey. Area 16 includes the entire coastal plain of New Jersey draining directly into the Atlantic Ocean. The Area is divided into two sub-areas: sub-area a includes the Manasquam River drainage, and sub-area b comprises the remaining coastal drainages. The Area is generally flat with marshland in the low lying areas along the coast. This coast is fronted by a wide barrier beach that has been extensively developed for recreation. There are 2,393 square miles in the Area.

The Area is 75 percent flatland which is 20 percent of all flatland in the N.A.R. The remainder is undulating land. Over one half of the Area is in forest-town landscape with the remainder in town-farm and city landscapes. Most of the Area consists of low with some medial visual quality. Sub-area b includes a unique vegetative region called the New Jersey Pine Barrens. This region provides a unique wilderness, recreation and natural scientific area. The shore line is one of the great flyways for migratory waterfowl.

The larger tracts of rich fertile soil induced early settlement of New Jersey. The settlers, besides farming, brought in large herds of livestock which helped to establish the tanning and leather industries. Urban growth spread from nearby New York City and by 1800 the Area, especially sub-area a, was fairly densely populated.

The population of Area 16 was 650,000 in 1960 is expected to increase by 254% to 2.3 million by 2020. Sub-area a had a population of 334,400, for a density of 899 people per square mile, while sub-area b had 317,700 people, or 157 per square mile. The Area as a whole had 272 people per square mile.

Per capita income was 9% above the national average in 1959 and is projected to remain at that level through 2020.

The 1960 employment of 230,000 is expected to increase to 870,000 by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; contract construction and public administration. Employment is expected to decrease in agriculture, forestry and fisheries; mining; food and kindred products; textile mill products; apparel and other textiles; and petroleum and coal products.

Water for withdrawal uses is available in the Area but is fairly widely dispersed. Careful management will be required to insure that the water supply can meet projected needs. Importation of water into the Area might become necessary if restrictions are placed on groundwater development and withdrawal in the southern part of the Area, where supplies must be maintained to support the Pine Barrens and prevent salt water intrusion. Summer pollution of coastal waters is a particular problem due to the influx of vacationers along the beaches

and the pollution from recreational boating. There is also some pollution of local coastal waters from municipal and industrial discharges and pollution of the beaches from solid waste disposal at sea.

Average annual runoff in Area 16 is approximately 2,450 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 968 m.g.d., and the corresponding seven-day minimum is about 80% of this total, or 781 m.g.d. (See Appendix C). The addition of 64 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 845 m.g.d., or 34% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,065 m.g.d., or 43% of the average runoff. Potential sources which would develop the increase of 220 m.g.d., include major storage, accounting for 38% of the increase; upstream storage, 52%, and ground water development, 10%.

Possible Alternative Planning Objectives. Each of the NAR planning objectives can be considered for Area 16. The proximity of New York City would lend the Area to National Efficiency as it could grow along with the national economy. This is especially true in the densely populated bedroom communities of sub-area a. Regional Development could be stressed by attracting more vacationers to the Area's beaches and waterways, benefiting the recreation industries. It must be noted, however, that the Area's per capita income is already at the national average.

Environmental Quality could be emphasized to upgrade the Area's natural resources, and to maintain them for the present users. This emphasis would limit population expansion and increases in the summer trade and the economy. The much larger population density of sub-area a could lead to different objective mix recommendations for each sub-area. The New Jersey Pine Barrens, located in sub-area b, could also require a different objective emphasis for that particular region.

Recommended Mixed Objective. Different planning objectives are recommended for the two sub-areas of Area 16. National Efficiency is recommended for sub-area a, because of its high population concentration and proximity to New York City. Some attention should be given to Environmental Quality and Regional Development, however, to maintain the sub-area's rural aspects.

The recommended mixed objective for sub-area b stresses Environmental Quality, primarily for beach preservation. This is augmented by both Regional Development and National Efficiency to induce summer vacationers to visit the coastal beaches and to maintain the employment and income levels of the permanent residents.

Needs To Be Satisfied. Needs for saline and brackish water withdrawals for power plant cooling in Area 16 are among the highest and fastest growing of the North Atlantic Region. This Area will export electricity because of the large quantity of water it has in relation to its low need for power. The needs for publicly supplied and industrial self-supplied water snd water quality maintenance are small but will be important to the Area's mixed objective as they grow at a high rate in the early phases of the planning period.

There will be an emphasis on the preservation of the Pine Barrens in sub-area b which may be a major constraint on water resource development in the immediate vicinity. These trees and the associated groups of plants and animals are very sensitive to variations in the water table and will require careful groundwater management. Some parts of the sub-area with deeper ground water can be developed however, as they do not directly support the Pine Barrens.

The large enclosed bays and extensive beaches of the coast are exceptionally well suited to support the Environmental Quality aspects of tbe mixed objective. There is also a fairly large population density in the Area which results in large needs for fish and wildlife, and visual and cultural. Included among these large needs are salt water access, piers, fishing mandays and access for nature observation. Large visual and cultural needs are for development of quality landscape.

Satisfying these environmentally related needs will help attain the Regional Development objectives by attracting vacationers to Area beaches and other recreation facilities. Water recreation and fish and wildlife needs grow very rapidly in this Area. Water quality maintenance will be key in meeting visual and cultural needs, especially since much of the solid waste disposed of at sea washes back up on the recreation beaches. There is a need to develop landscape quality since the Area is presently almost all low visual quality.

Rural water supply, drainage control, commercial navigation and most erosion control needs are relatively insignificant although they have a steady growth rate over the planning period. Coastal erosion needs, however, are large and grow rapidly and will adversely affect water recreation needs if allowed to continue unfulfilled.

Tidal flood damage reduction needs are very large in this Area because of the generally low elevation of its coast. The other flood damage reduction needs, however, are very small in this Area because of the small drainages and the lack of concentrated development. There are no hydroelectric power generation needs.

Devices. Power plant cooling needs will be met by saline and brackish withdrawals and cooling facilities to prevent excessive thermal pollution. Thermal discharges, however, may be used to extend the normal water recreation season.

Some surface storage in sub-area a, along with fresh and brackish water intakes and groundwater throughout the Area, will be the principal devices for meeting the needs of agriculture irrigation and publicly supplied water. Storage devices will also help meet the needs for fish and wildlife, visual and cultural and water quality maintenance. Groundwater management will be used in the Pine Barrens. Water/Land management devices will be the principal means of fulfilling the needs of erosion and drainage control and will help meet the fish and wildlife and visual and cultural landscape needs. Land control will be used to attain the remaining visual and cultural and fish and wildlife needs.

Developing water resources for fish and wildlife needs will require fee simple purchase, purchase lease and zoning of land for public access. Recreational boating needs will require extensive recreation boating facilities especially on the coast. Water quality maintenance will require secondary and advanced treatment plants, ocean outfalls for sewage, separation of combined sewers, nutrient control and septic tank controls. Water quality standards enforcement for encephalitis control along with shark protection will be utilized to protect water recreationists.

The prevention of coastal dune destruction will be achieved by land use legislation along with physical devices that include ocean projects and coastal shoreline devices. These devices will be significant in meeting the needs of tidal and hurricane flood damage reduction and coastal erosion control. Meeting these needs will also allow those visual and cultural and water recreation needs to be filled that depend upon retention of a good shoreline.

Benefits. The development of special groundwater management procedures for sub-area b will provide large benefits for the Pine Barrens. Satisfying water withdrawal needs, especially in sub-area a, will have fairly large benefits by providing for the Area's economic and population growth.

Large benefits will be produced by the use of the recommended water quality control facilities especially in sub-area a with its higher population density. Benefits will be large for visual and cultural and water recreation needs as the water quality standards are met. Water quality maintenance will enhance the quality of natural resources in sub-area a and preserve them in sub-area b. Fulfillment of beach erosion control needs will produce significant benefits to the Area's recreation income as they prevent destruction of many of the coastal beaches.

High benefits will occur by satisfying recreational boating and fish and wildlife needs because of the activity in commercial and sport fishing and other boating activities offshore and along the coast. Recreation oriented devices will also yield benefits due to the importance of this activity in the economy of the Area. Meeting health needs for insect and shark protection will add to recreation benefits.

Costs. Water quality maintenance, visual and cultural and erosion control will have the highest costs throughout the planning period. Tidal and hurricane flood damage reduction needs will have large costs in the first planning period. The other costs will be small, though the largest of them will be navigation, irrigation water, and fish and wildlife. Initial costs for land acquisition to satisfy visual and cultural and fish and wildlife needs will be high because land must be obtained now to avoid rising costs.

Meeting power plant cooling needs may hamper the meeting of fish and wildlife needs because of the possible disruption of natural habitats from thermal pollution and from the danger to some organisms by intakes. Increases in recreational activities will raise health costs as insect controls are used for tourist comfort and shark protection is used for coastal swimmers.

Alternative Programs. Alternative programs for Area 16 can not offer large variations. This is because the variations between the needs of the Area are relatively small and the types of water resources in the Area do not offer a large variety of opportunities for development.

If Regional Development were chosen for primary emphasis there would be fairly large increases in the needs for agricultural irrigation and small increases in cropland drainage control and water recreation needs. Different devices would be used to meet water recreation, flood damage reduction, and power plant cooling needs. There would be reduced needs for streambank and shoreline erosion to reduce costs. The water resources of Area 16 would be stretched to their limits to meet the increased needs required for a Regional Development program. Agricultural irrigation needs and costs would increase significantly in sub-area b, especially in the second planning period, but they would decrease in sub-area a as agriculture would give way to homes and industry. Power plant cooling needs would be met by increases in brackish and fresh water withdrawals and consumption during the second and third planning periods. This would satisfy increased regional growth power needs and reduce the use of salt water. The increased needs for water recreation would be filled by higher density use at a larger cost. Cropland drainage control would be increased to aid agricultural production in sub-area b. Upstream flood damage reduction needs would be met by increased use of reservoirs, river projects and watershed management in the last time period.

If National Income objective were to receive primary emphasis there would be only a few changes from the recommended program. Power needs would be essentially the same, although, more brackish and saline water withdrawals would take place with an elimination of the additional costs. There would be slight decreases in agricultural and urban erosion control needs and large deductions in streambank and shoreline erosion needs. Visual and cultural needs in the form of high quality landscapes would drop slightly. There would be cost reductions for visual and cultural needs as development of quality

landscapes would be reduced and the use of purchase leases would be decreased.

If Environmental Quality were chosen, agricultural irrigation needs would have a large increase in the second planning period. Power plant cooling needs would be met by increased use of fresh water withdrawals and brackish and freshwater consumption. Saline and brackish withdrawals would not grow as rapidly during the last two planning periods to reduce the impact of thermal waters upon coastal recreation. Costs would increase substantially. Water recreation needs and costs would have a large increase. Fulfillment of water recreation needs would be aided by a large increase in river and stream miles, water surface acres, beaches, pools and facilities. Flood plain and watershed management would be used to a much larger extent to meet upstream flood damage reduction needs. This would help preserve the flood plains for visual and cultural and water recreation needs. Drainage control for cropland would be increased slightly.

AREA 16

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	90	130	230	350
Industrial Self-Supplied Water (mgd)	5	14	25	38
Rural Water Supply (mgd)	3.0	3.9	5.2	5.6
Irrigation Water: agriculture (1000 afy)	14	45	45	45
non-agriculture (1000 afy)	3	8	12	18
Power Plant Cooling: withdrawal, saline (cfs)	0	3000	14000	36000
brackish (cfs)	300	300	3300	6700
fresh (cfs)	0	0	0	0
consumption, brackish (cfs)	3	3	33	69
fresh (cfs)	0	0	0	0
Hydroelectric Power Generation (mw)				
Navigation: commercial (m. tons annually)	0.3	0.4	0.8	1.3
recreational boating (1000 boats)	22	27	50	66
Water Recreation: visitor days (m.)	x	21	37	70
stream or river (miles)	x	39	63	87
water surface (1000 acres)	x	8	13	19
beach (acres)	x	120	200	340
pool (m. sq. ft.)	x	2.4	3.9	6.7
land facilities (1000 acres)	x	4.3	6.7	11.0
Fish & Wildlife: sport fishing man-days (m.)	7.3	8.3	10.4	12.9
surface area, lake (acres)	x	100	700	1400
stream (acres)				
access, fresh (acres)	x	8	24	42
salt (acres)	x	900	2600	4700
anadromous (acres)	x	2	3	4
piers (1000 feet)	x	20	70	130
hunting man-days (m.)	0.64	0.72	0.87	1.06
access (1000 sq. mi.)	x	0	0.2	0.3
nature study man-days (m.)	1.6	1.9	2.3	2.9
access (1000 acres)	x	8	21	36
Water Quality Maint.: non-industrial (m. PEs)	1.5	0.8	1.0	1.3
industrial (m. PEs)	0.6	1.4	3.5	8.2
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	0.7	0.10	0.17	0.31
mainstream (m.$)				
tidal & hurricane (m.$)	5	7	14	28
Drainage Control: cropland (1000 acres)	19	25	40	43
forest land (1000 acres)	x	0	8	33
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	75	82	89	91
urban (1000 acres)	220	250	320	420
stream bank (mi.)	x	8	24	40
coastal shoreline (mi.)	x	92	199	227
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	x	300	300	300
unique shoreline (mi.)	x	30	30	30
high quality (sq.mi.)				
diversity (sq.mi.)				
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	100	200	300
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	16	16	16

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	130	210	290	130	230	350	130	290	350
	14	22	32	14	25	38	14	26	41
				3.9	5.2	5.6			
	60	95	95	45	45	45	60	95	95
	8	12	18	6	10	18	6	12	18
	3000	8000	16000	3000	11000	19000	3000	10000	12000
	300	2500	5500	300	6800	20600	300	4100	18900
	0	60	60	0	30	50	0	80	180
	3	113	254	3	70	223	3	102	362
	0	26	33	0	14	24	0	39	89
	0.3	0.5	1.0	0.4	0.8	1.3	0.5	0.9	1.5
				27	50	66			
	25	43	81	21	37	70	25	44	81
	119	192	264	39	63	87	59	95	130
	30	41	69	8	13	19	16	25	36
	340	540	910	120	200	340	150	240	410
	5.8	9.2	15.9	2.4	3.9	6.7	3.0	4.8	7.9
	23.3	36.3	60.0	4.3	6.7	11.0	8.2	12.8	20.6
				8.3	10.4	12.9			
				100	700	1400			
				8	24	42			
				900	2600	4700			
				2	3	4			
				20	70	130			
				0.72	0.87	1.06			
				0	0.2	0.3			
				1.9	2.3	2.9			
				8	21	36			
				0.8	1.0	1.3			
				1.4	3.5	8.2			
				0.10	0.17	0.31			
				7	14	28			
	29	48	49	25	40	43	29	48	49
				0	8	33	8	33	109
	82	89	91	79	83	85	82	89	91
	250	320	420	230	290	370	250	320	420
	8	24	40	2	6	10	4	12	20
	92	199	227	3	10	17	7	21	35
	x	x	x	x	x	x	x	x	x
	300	300	300	300	300	300	Same	as EQ	
	30	30	30	30	30	30	Same	as EQ	
	100	200	300	50	100	150	Same	as EQ	
	16	16	16	16	16	16	Same	as EQ	

AREA 16

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,VC	9.7*	x*	x*
mainstream (1000 af)	FW,VC,WQ	x	x	15.3ɫ
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Irrig	17	19	10
brackish (mgd)	Ind	18	23	19
estuarine (mgd)	Pow	x	x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		0*	0*	36*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow	x	x	x
chemical/biological				
potable water treat plants (mgd)				
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC	1.9	0	0
secondary (90%) (m. PE removed)	WQ	0	4.1	8.6
advanced (95%) (m. PE removed)	WQ	0	0.23	0.48
effluent irrigation	WQ,VC	x	x	x
nutrient control	WQ,VC	x	x	x
stormwater discharge control				
acid mine drainage control				
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x		
Pumped Storage				
Desalting Facilities		0*	0*	6.0*
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	1	x	x
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)	FDR	4	0	0
river (projects)				
flood control channels (mi.)				
Watershed Management (1000 acres)	Drn,VC	x	x	x
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec,VC	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
**Also includes the following purposes: PS,Ind,Irrig
ɫ Also includes the following purposes: VC,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig ≁	20.4	16.0	x	Irrig ≁	13.7	x	x	Irrig ≁	20.4	16.0	x
PS,WQ ≁	3.5	3.1	x	PS,WQ ≁	4.0	3.8	x	PS,WQ ≁	4.1	3.8	x
Pow**	15	15	10	Pow**	17	19	10	Pow**	17	19	10
Ind	36	36	32	Ind	36	44	36	Ind	38	52	51
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	55	78	63	Rur**	51	73	86	Rur**	93	92	87
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
				WQ,VC	1.9	0	0				
				WQ	0	4.1	8.6				
				WQ	0	0.23	0.48				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x								
WQ,VC	x			WQ,VC	x			WQ,VC	x		
FDR,VC	4	122	203	FDR,VC	1	x	x	FDR,VC	1	x	x
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	4	0	0	FDR	4	0	0	FDR	4	0	0
								FDR	0	0	1
FDR,Drn,VC	123	246	246	Drn,VC	x	x	x	Drn,VC	x	x	38
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x	x	Nav	x	x	x
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 16

DEVICES—incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	150	0	0
fee simple purchase (buying) (mi.)	VC, FW	15	0	0
purchase lease (sq.mi.)	VC, FW	120	100	100
easements (sq.mi.)				
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC,FW	150	0	0
zoning (mi.)	VC, FW	15	0	0
zoning and/or tax inc. subs.(sq.mi.)				
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs				
change project design load	Rec	x	x	x
V. Others				
Shark and Encephalitis Control	Hlth	x	x	x
Ground Water Management	VC, FW	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	420	100	100	VC, FW	150	0	0	Same	as	EQ	
VC, FW	30	0	0	VC, FW	15	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	70	50	50	"	"	"	
VC,FW	0	0	0	VC,FW	150	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	15	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
Pow			x								
FW	x	x	x	FW	x	x	x	FW	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x

AREA 16

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	1.2*	0*	0*	
mainstream	0*	0*	11.4*	
wells	0*	0*	1.7*	
desalting	0*	0*	13.0*	
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	0,06	0,06	0	
industrial self-supplied water	0,24	0.27	0.25	
rural water supply	x	x	x	
irrigation, agriculture	3.8	0	0	
nonagriculture	3,1	3,3	4,1	
Power Plant Cooling Water	0	1.5	3	
Hydroelectric Power Generation				
Navigation: commercial	10	10	5	
recreation	6,4	14,4	15,8	
Water Recreation	2.4	6,4	6.4	
Fish and Wildlife: fishing	3,4	6,6	7,7	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	240	490	1020	
advanced	0	51	94	
other ≠	26	0	0	
Flood Damage Reduction: upstream	0	0	0	
mainstream	160	0	0	
Drainage Control	0.48	1.52	1.24	
Erosion Control	79	100	39	
Health	x	x	x	
Visual and Cultural	219	50	50	
Summation of Available Estimated Costs	760	740	1270	

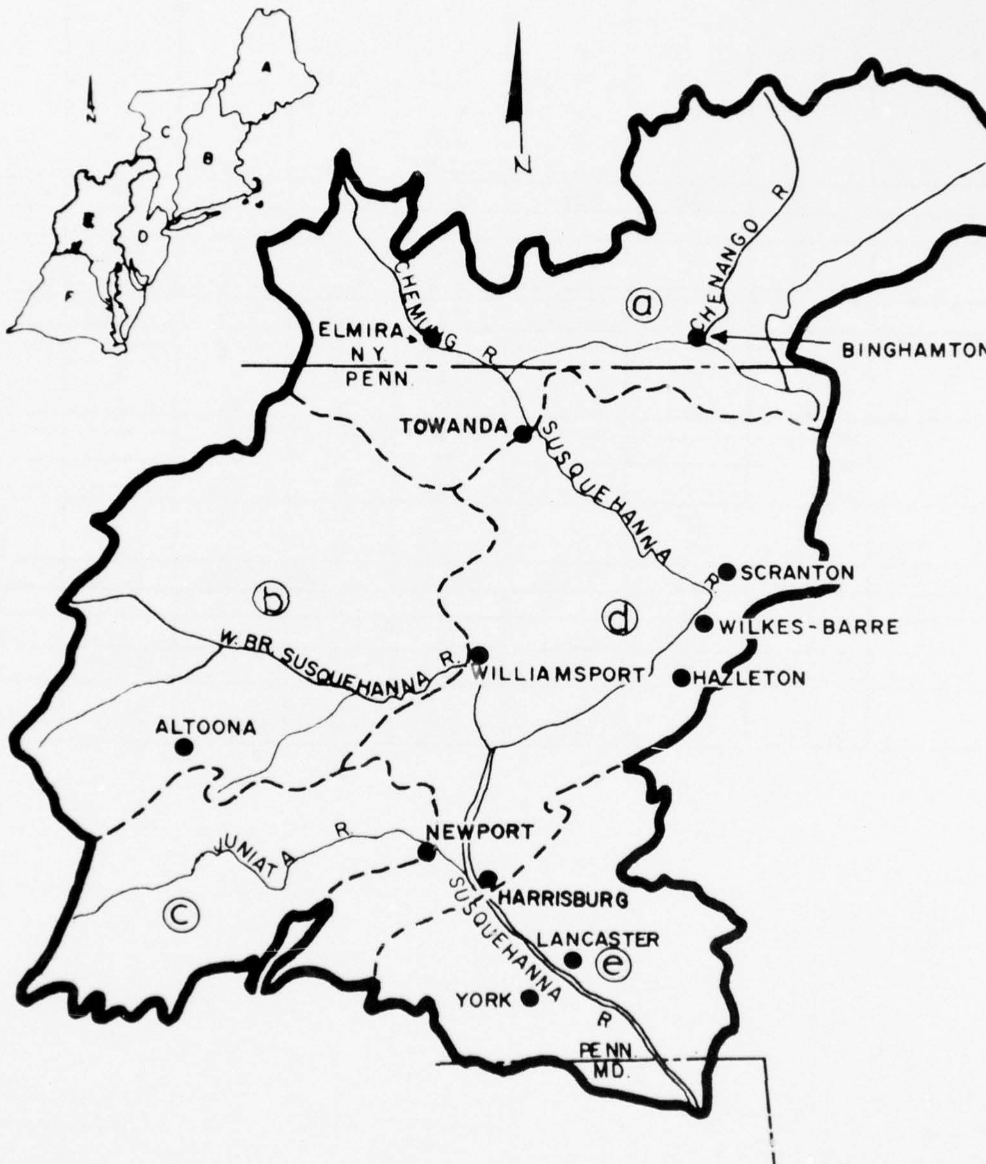
*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

AREA 16

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	0,9	0,9	0	0,6	0	0	0,9	0.9	0
	3,8	3,4	0	4,3	4,1	0	4,5	4.1	0
	3,2	4,4	3.7	2,8	6.9	4.9	3.4	5.1	4.9
	0	0	0	0	0	0	0	0	0
	0.05	0.05	0	0,06	0,06	0	0.06	0.06	0
	0,24	0,24	0.24	0,24	0,27	0,25	0.24	0.32	0.33
	x	x	x	x	x	x	x	x	x
	5,9	5,4	0	3,8	0	0	5.9	5,4	0
	3,1	3,3	4.1	2,6	3,2	4,6	2.7	3,4	4,2
	0	98	426	0	0	0	0	84	285
	0	0	0	10	10	5	10	10	5
	←			6,4	14,4	15,8			→
	23,6	19,4	22,0	2,4	6.4	6,4	7.7	9.5	9.2
	←			3.4	6,6	7,7			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			240	490	1020			→
	←			0	51	94			→
	←			26	0	0			→
	0	0	0	0	0	0	0	0	0.1
	160	0	0	160	0	0	160	0	0
	0,80	1,84	1,08	0,48	1,52	1,24	1,12	2,51	3,11
	79	100	39	4	15	18	10	23	27
	x	x	x	x	x	x	x	x	x
	576	50	50	194	25	25	Same	as	EQ
	1130	850	1680	660	630	1200	1060	760	1530

AREA 17 SUSQUEHANNA RIVER BASIN



AREA 17

Susquehanna River Basin. Area 17 is the Susquehanna River Basin that drains an area of about 27,510 square miles - 6,309 in New York, 20,927 in Pennsylvania, and 274 in Maryland. The Susquehanna River, which rises at Otsego Lake in New York, flows 450 miles through intensively developed industrial areas, through productive farmlands, and through long stretches of unbroken forests, finally merging with tidal waters of the Chesapeake Bay. The Area has been divided into five sub-areas: a is the Susquehanna River above Towanda, Pa.; b is the West Branch of the Susquehanna River above Williamsport, Pa.; c is the Juniata River above Newport, Pa.; d is the Susquehanna River above Harrisburg, Pa.; and e is the remainder of the basin, south from Harrisburg.

The predominant land form in the Area consists of rolling hills with lesser amounts of steep hills and undulating land. One quarter of the Area is step and rolling hills equally mixed. The major landscape pattern -- 50 percent of the Area -- is divided between town-farm and forest wildland with another quarter in forest-town. The remainder is farm and city landscapes. The Area consists of equal amounts of medial and low visual quality.

Early settlement of the Area was the result of a more moderate climate than New England, combined with more fertile and less stony soils. The 18th century saw large-scale development in the Area but it is still relatively undeveloped when compared with other nearby Areas.

The 1960 population of 3.2 million is expected to increase to 6.1 million by 2020. The population density for the Area is 116 people per square mile. Sub-area b has the lowest density with only 62 people per square mile and sub-area e has the highest with 198 people per square mile.

Otsego Lake is in the north-east portion of sub-area a from which the Susquehanna River flows south and then west to the center of the sub-area. The Chemung River forms the western part of this sub-area flowing east and joining the Upper Susquehanna at Athens, Pennsylvania. The sub-area has nearly level to moderately sloping plateaus and narrow valleys with steep walls. Farms and cutover mixed hardwood forests cover the sub-area. Binghamton and Elmira, N.Y. are centers of economic activity.

The West Branch of the Susquehanna River rises in the Appalachian Plateau in the western portion of sub-area b. This branch flows through mountainous forest-wildland landscape to its junction with the Susquehanna River at Sunbury, Pa. Coal mines above Williamsport are critical sources of pollution in sub-area b which has the lowest population density of the Area, 62 people per square mile.

The Juniata River of sub-area c flows through undulating and rolling valleys with hilly slopes and through steep Appalachian mountain ridges to join with the Susquehanna River 38 miles below the West Branch. Altoona, Pa., is the only large town in sub-area c which consists primarily of forest-wildlife landscape.

Over one-third of the Area's residents live in sub-area d. Scranton, Wilkes-Barre-Hazleton, and Harrisburg are the three large metropolitan areas in the sub-area. The Susquehanna River in this sub-area flows through forest-town and town-farm landscapes, by the Dutch Amish Country and through Harrisburg, Pa. the second largest city in the Area. Scranton is the largest city in the Area.

Sub-area e the most densely populated of the sub-areas, begins immediately below Harrisburg. The sub-area consists of the gently to strongly rolling Piedmont which is evenly divided between farm and suburban landscapes. The Dutch Amish Country in this sub-area is located east of Lancaster.

Per capita income of the Area was 10% below the national average in 1959 and is projected to increase to only 5% below by 2020. Income is especially low in sub-areas b,c, and d going as much as 20% below the national average in some sections.

Employment is expected to increase significantly from its 1960 level of 1,177,519 to a 2020 level of 2,405,700. Industries with the largest 1960 employment include services; wholesale and retail trade; transportation, communication and public utilities; and machinery. Employment is expected to decrease in agriculture, forestry and fisheries; mining; textile mill products; apparel and other textiles; and primary metals.

Water is generally abundant in the Area. Pollution in portions of the Area, however, makes some of this water unavailable for certain uses. Acid mine drainage exists in the West Branch (sub-area b), Tioga (a), Juniata (c) and Lackawanna Rivers (d). Three major river segments are degraded by municipal and industrial pollution. They are: the Susquehanna River below Binghampton (sub-area a), the Chemung River below Elmira (a), and the Susquehanna River below Wilkes-Barre (d).

A comprehensive study (Type II) of the water and related land resources of the Susquehanna River Basin has recently been completed. The Baltimore District, U. S. Army Corps of Engineers, managed this study and coordinated the efforts of the Federal agencies and states in the basin. The report by the study's Coordinating Committee will serve as the starting point in the formulation of a comprehensive river basin management plan by the Susquehanna River Basin Commission just established by a compact between the basin states and the Federal government.

Average annual runoff in Area 17 is approximately 24,890 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 2,470 m.g.d., and the corresponding seven-day minimum is about 52% of this total, or 1,280 m.g.d. (See Appendix C). Allowance for yield from Lake Raystown raises the latter value to about 1,530 m.g.d. The addition of 211 m.g.d. for consumptive losses and export to Area 15, results in a firm resource available for use of 1,741 m.g.d., or 7% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 8,756 m.g.d., or 35% of the average runoff. Potential sources which would develop the increase of 7,015 m.g.d., include major storage, accounting for 52% of the increase; upstream storage, 27%, and ground water development, 21%.

Possible Alternative Planning Objectives. Each of the NAR planning objectives can be given primary emphasis in Area 17. Two limitations, however, seem to apply. The Area is so diverse - including types of industries, population densities, types of water problems and income levels - that the mixed objective should differ by sub-area and by state. Second, there are such large income, environmental and recreational problems in the whole Area, that no matter which objective is emphasized in a sub-area, Environmental Quality and Regional Development should be given some attention.

Recommended Mixed Objective. The recommended mixed objective in Area 17 varies by state and by sub-area and primarily emphasizes Environmental Quality and Regional Development.

The water resources management program for New York State's portion of sub-area a should equally emphasize Regional Development and Environmental Quality. This mixed objective will help satisfy the needs of this portion of the Area caused by pockets of economic underdevelopment and by increasing recreation and environmental quality pressures.

A large part of Pennsylvania's portion of the Area is economically underdeveloped and, as a result, is given a Regional Development emphasis. Included under this emphasis are Pennsylvania's portions of sub-areas a and e, the northern and eastern portion of b, all of c, and all except the eastern portion of d. Because of environmental and recreational problems in some portions of the sub-areas just mentioned -- problems that include water pollution and recreation pressure -- some attention is given to Environmental Quality in Pennsylvania portion's of sub-area a, in the northern portions of b and d, in the southern tip of d and in all of Pennsylvania's portion of e except the northern tip. Because of large acid-mine drainage pollution problems an Environmental Quality emphasis is given to the southern portion of sub-area b, the eastern portion of d and the northern tip of e. Some attention is given to Regional Development in these same portions of sub-areas b, d and e because they also have low income levels.

Maryland's portion of the Area should be given an Environmental Quality emphasis because of its proximity to Baltimore and the large recreation needs of its population. Some attention should also be given to National Efficiency in this portion of sub-area e because it can generally increase its economic position without outside help.

Needs to be Satisfied. The key and most difficult need in the Area is water quality maintenance. The achievement of the mixed objective anticipates the growth of the Area's population and industrial and recreational activities. This requires a vigorous compliance with established water quality standards. Concurrent with the key and fairly large water quality maintenance needs are the large, important and rapidly growing needs for publicly supplied and industrial self-supplied water and for supplying water to nearby Areas. Presently, there are transfers to Baltimore, Maryland, and Chester, Pennsylvania. The satisfaction of the need for dependable supplies of clean water throughout the planning period will allow the orderly growth of a variety of industries while retaining the Area's high environmental quality.

Important to the entire Area will be the large and rapidly growing needs for recreation and fish and wildlife. Visual and cultural needs will also be large and important to the Area for maintaining and developing landscape diversity and agricultural landscape and for preserving unique natural areas. The earliest possible satisfaction of these environmentally related needs will establish the pattern of development for the mixed objective and preserve many of the highly desirable environmental qualities of the Area.

Power plant cooling needs will be very high in terms of the total freshwater withdrawals and consumption. The growth rate of water use in power plants is high and will be greatest during the first two planning periods. Power plant cooling needs will be large because the Area, which is close to large centers of energy use, has a large quantity of low cost fuel and dependable supplies of water.

Hydroelectric power generation needs of Area 17 are very large and fast growing over the planning period. The mountainous characteristics of the northern and western portions of the basin provide many potential sites for pumped storage facilities which will make it possible to provide for the peak power needs of nearby Areas.

Flood control is no longer the overriding problem that it once was in the Area. Existing and planned controls reduce the damage from recurrent storms. Needs for flood damage reduction, however, still remain among the highest and fastest growing in the Region. Measures will be required for all planning periods in local parts of the Area.

Navigation needs will be limited primarily to recreational boating since commercial navigation is severely restricted by main stem impoundments. Recreational boating needs are anticipated to grow moderately fast throughout this planning periods as a general reflection of increase leisure time.

This will be concentrated in the downstream portion of the Area where local population pressures will accelerate its growth.

Irrigation needs are very large in the Area and are relatively important because of the amount of water consumption involved. The needs for drainage and erosion control have been effectively dealt with in the past but are large, grow fairly rapidly and are fairly important in the over-all scheme of meeting the mixed objective. Health needs of the Area include pollution control to promote economic development and insect control to enhance water recreation and environmental quality. Rural self-supplied water needs will remain fairly constant in the early time frames and then decrease as central systems expand. These are among the largest of rural needs in the NAR.

Devices. The most important devices will be reservoirs, intakes and pumping stations, cooling facilities, waste treatment plants, nutrient control, acid mine drainage control, and separation of combined sewers. All of the above will provide for the water withdrawal and visual and cultural needs of the Area.

Quality control facilities and water storage facilities will enable Area 17 to develop adequate provisions for industrial growth without undue detrimental effects to the quality of the environment. The needs of water recreation and fish and wildlife will also require early application of these same devices for water surfaces. Fish and wildlife needs will, in addition, require habitat management, fishways and fish and wildlife stocking, besides land access to recreation and fish and wildlife sites. Visual and cultural needs can best be met by the use of fee simple purchase and easements for the preservation of unique natural landscapes and landscape diversity. Fresh and brackish water intakes, wells, and small upstream reservoirs will be required to meet the needs of agricultural irrigation in the early phases of this Study and will also serve the visual and cultural needs for upgrading the landscape by maintaining agricultural lands in production.

Power installations will be required in all sub-areas, with the bulk of the development occuring in the sub-areas c and d. The use of cooling facilities for power plant cooling will be important in all time frames. In conjunction with cooling facilities there will be some development for non-condensing base load power in late phases of this study. The combination of these devices will help satisfy the mixed objective by providing a power supply for Regional Development while safeguarding the Area's environmental quality. Hydroelectric needs can best be met by pumped-storage devices that can make use of the Area's potential for economical sites.

Water quality maintenance and health needs cannot be entirely met without research on problems that presently have no solutions. These problems include monitoring and extraction of some of the more difficult heavy metal pollutants and virus diseases.

The following devices will help to attain the Area's Regional Development objectives by improving upon its economic competitiveness and industrial base. Reservoirs, watershed management and river projects will meet most upstream flood damage reduction needs but will require some help from flood plain management. Mainstream flood damage reduction will use river projects and reservoirs with more flood plain management which can be fairly effective in the relatively undeveloped portions of the Area.

The Watershed management for flood damage reduction will also aid visual and cultural needs. Navigation needs will be met by port improvements and recreational boating facilities. Drainage control needs will require watershed management and drainage practices and erosion control needs will require erosion protection for land and river shorelines.

Benefits. Large benefits will result from the satisfaction of water quality maintenance needs because of the dependency upon water of good quality by the Area's publicly supplied and industrial self-supplied needs. These benefits would be primarily economic. Certain environmental benefits however, will also be realized. The elimination of acid mine wastes will restore plant and fish life, and conformance with water quality standards would benefit certain instream uses, such as recreation and fish and wildlife, which require high quality water. Large economic benefits will be realized by Area 17 as it satisfies regional power needs. Environmental benefits will accrue to adjacent areas as some of their regional power needs are satisfied in Area 17 which can help meet their needs with less harm to its environment.

Large benefits to Area 17 will result from satisfying visual and cultural, fish and wildlife, and water recreation needs. Visual and cultural and fish and wildlife land control devices complement each other and increase the benefits to both needs. A primary benefit from such devices in this Area will be the preservation of land used by wild fowl migrating between northern and southern portions of North America.

Significant recreational benefits will accrue from the recommended program to the people of nearby areas who utilize Area 17 as their major source of recreation. This recreation will in turn result in some economic benefits to Area 17.

Reservoirs, as devices, will complement the water surface and storage needs of visual and cultural, water recreation, flood damage reduction and health needs in Area 17. Reservoirs may also provide significant ecological benefits for Area 18 by providing additional control on fresh water inflow to the upper Chesapeake Bay. This control may greatly benefit the shell fish resources of the Bay. Much additional study is needed to be sure that operation of upstream reservoirs provide benefits for the Bay.

Costs. The suggested program has large monetary costs as a result of the emphasis on Regional Development and Environmental Quality. Hydroelectric generation costs will be very large as use is made of the extremely valuable sites in the Area. The costs for the power plant cooling, erosion control, water recreation, water quality maintenance and visual and visual-cultural needs are much greater than those to satisfy other needs. This is due to Area 17's large size, abundant water resources, large degree of waste treatment required and great recreational potential. The necessity of using fee simple purchases to adequately protect unique landscapes and diversity also raises costs.

Industrial water use, power plant cooling and irrigation will result in significant ecological and environmental costs to Area's 18 and 17 as these needs exert the greatest consumptive demand on river flow at the time when it is lowest. A significant decrease in river flow would also result in a change in the level of salinity in the upper Chesapeake Bay.

Costs will be high as power plant cooling and hydroelectric generation needs conflict with fish and wildlife and visual and cultural needs. Increased water temperature may be physically harmful to some fish species and indirectly harmful to all aquatic life because of the lower oxygen level of such water. Fresh and brackish water intakes may also trap some fish species in the cooling system. The alternative, cooling facilities, is considered by some to be incompatible to an acceptable visual environment and to be too expensive to use extensively.

Reservoirs will result in ecological costs in Area 17 unless careful and often economically expensive remedies are used. The ecological problems include obstruction of fish migrations. increases in water temperatures and changes in nutritional content of the waters. These effects may also all cause changes in the variety of fish and other marine live within and below the reservoirs. Other significant costs of reservoirs in this Area include relocation of transportation facilities, utilities and occupants of the sites as well as the loss of farm lands and tax bases.

Alternative Programs. If Environmental Quality were chosen to be emphasized throughout Area 17, the needs of agriculture irrigation, water recreation, and drainage control would be larger while those of publicly supplied and industrial self-supplied water would be lower. Irrigation needs for agricultural land would be much larger which would require a considerably larger investment. Emphasis would be placed on improving the over-all water recreation experience by reducing visitor days and increasing the other need and cost levels of water recreation. The approach to upstream flood damage reduction would change dramatically as the use of all devices would be greatly increased except for flood control channels. Mainstream flood damage reduction would be achieved by slightly less storage and river projects in the first time period. Power plant cooling needs would include less withdrawal and consumption of fresh water.

If Regional Development were chosen to be emphasized throughout Area 17, the needs of irrigation, power plant cooling and drainage control would be higher. The need for irrigation of agricultural land would be much larger resulting in a much larger investment. Water quality maintenance needs would be met without the use of septic tank control and less use of research. Drainage control needs would be increased with the purpose of increasing productivity of forest and croplands and with the result of increasing the economic return of this industry. Power plant cooling needs would be larger because of the use of non-condenser facilities. The withdrawal of fresh water would rise while its consumption would decrease in the first time period but increase during the last two periods. Water recreation visitor day needs would increase very slightly but the costs would decrease as the use of rivers, water surface, beaches, pools and land facilities would be decreased to attain low quality recreation experiences, Streambank erosion control needs would be reduced.

If National Income were chosen to be emphasized throughout Area 17, the needs of publicly supplied and industrial self-supplied water, erosion control, drainage control and agricultural irrigation would be lower. Water recreation would be de-emphasized by reducing all needs and costs. Erosion control needs would be reduced. Power plant cooling needs would be larger as non-condenser devices would not be used. More fresh water withdrawals and less freshwater consumption would be needed. Water quality maintenance needs would be met by the use of only wastewater treatment, mainstream reservoirs and acid mine drainage control. Upstream flood damage reduction would be achieved by fewer quantities of all types of devices. Mainstream flood dmaage reduction would be achieved by slightly less storage and river projects in the first time period. Visual and cultural needs would be reduced for development of landscape diversity and metropolitan amenities. These costs would also be reduced by shifting from fee simple purchase to purchase lease and zoning and/or tax incentive subsidy.

AREA 17

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	340	450	690	1100
Industrial Self-Supplied Water (mgd)	370	640	1240	2230
Rural Water Supply (mgd)	62	81	100	94
Irrigation Water: agriculture (1000 afy)	10	80	100	130
non-agriculture (1000 afy)	7	23	40	63
Power Plant Cooling: withdrawal, saline (cfs)				
brackish (cfs)				
fresh (cfs)	2700	3400	6900	10100
consumption, brackish (cfs)				
fresh (cfs)	30	170	290	470
Hydroelectric Power Generation (mw)	2000	3000	12000	33000
Navigation: commercial (m. tons annually)	0.05	0.10	0.12	0.15
recreational boating (1000 boats)	70	80	140	210
Water Recreation: visitor days (m.)	x	80	130	240
stream or river (miles)	x	390	580	770
water surface (1000 acres)	x	90	130	180
beach (acres)	x	1300	1900	3000
pool (m. sq. ft.)	x	22	32	52
land facilities (1000 acres)	x	50	75	118
Fish & Wildlife: sport fishing man-days (m.)	8	10	12	15
surface area, lake (acres)	x	0	3700	15700
stream (acres)				
access, fresh (acres)	x	210	560	1000
salt (acres)				
anadromous (acres)	x	62	78	98
piers (1000 feet)				
hunting man-days (m.)	7	8	10	13
access (1000 sq. mi.)	x	0	1.4	3.6
nature study man-days (m.)	4.3	5.1	6.4	7.9
access (1000 acres)	x	2.0	5.6	9.4
Water Quality Maint.: non-industrial (m. PEs)	3.2	3.9	4.9	6.1
industrial (m. PEs)	1.3	2.9	5.9	11.5
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	4	7	14	29
mainstream (m.$)	11	17	34	73.
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	230	320	430	430
forest land (1000 acres)	x	4	18	63
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	4400	5900	7000	7100
urban (1000 acres)	1400	1600	2100	2900
stream bank (mi.)	0	110	340	570
coastal shoreline (mi.)				
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	1000	1000	1000	1000
unique shoreline (mi.)				
high quality (sq.mi.)				
diversity (sq.mi.)	x	300	600	900
agriculture (sq.mi.)	x	250	250	250
landscape development, quality (sq.mi.)				
diversity (sq.mi.)	x	300	300	300
metro. amenities (mi.)				
" " (sq.mi.)	x	75	75	75

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	430	630	900	450	680	1050	450	700	1100
	630	1100	1790	630	1160	2010	640	1240	2230
				81	100	94			
	520	1600	2130	40	60	70	520	1600	1620
	25	43	64	23	40	63	24	41	63
	3600	2300	800	3600	15900	25500	3600	7800	13800
	150	230	280	150	270	500	150	300	550
				3000	12000	33000			
	0.06	0.08	0.10	0.09	0.11	0.13	0.10	0.12	0.15
				80	140	210			
	80	130	240	80	120	210	80	130	240
	520	770	1040	170	260	340	260	380	510
	110	170	240	30	50	60	60	90	120
	1400	2100	3400	400	600	1000	1100	1600	2600
	25	36	60	8	11	19	19	28	45
	73	110	175	15	20	32	27	39	60
				10	12	15			
				0	3700	15700			
				210	560	1000			
				62	78	98			
				8	10	13			
				0	1.4	3.6			
				5.1	6.4	7.9			
				2.0	5.6	9.4			
				3.9	4.9	6.1			
				2.9	5.9	11.5			
				7	14	29			
				17	34	73			
	340	450	450	300	410	410	340	450	450
	0	7	29	0	7	29	7	29	96
	5900	7000	7100	5300	5900	6000	5900	7000	7100
	1600	2100	2900	1400	1800	2400	1600	2100	2900
	110	340	570	20	80	140	60	170	280
		x	x	x	x	x	x	x	x
	1000	1000	1000	1000	1000	1000	Same	as	EQ
	300	600	900	300	600	900	Same	as	EQ
	250	250	250	250	250	250	Same	as	EQ
	300	300	300	150	150	150	Same	as	EQ
	75	75	75	40	75	75	Same	as	EQ

AREA 17

DEVICES-incremental	MIXED OBJECTIVE Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	60*	30*	60*
mainstream (1000 af)	FW,Rec,VC,WQ	90*	150*	510*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	⨍PS,Ind,Pow,Irrig	260	540	880
brackish (mgd)				
estuarine (mgd)				
ocean (mgd)				
wells (mgd)		90*	230*	30*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)		200*	40*	530*
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	46	108	180
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	6.1	9.7	15.9
advanced (95%) (m. PE removed)	WQ,VC	0.34	0.54	0.88
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control	WQ,VC	x	x	x
septic tank control	WQ,VC	x	x	x
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG	x	x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	0.2	1.8	1.0
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	9	3	8
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	100	90	370
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement				
debris removal				
recreation boating facilities	Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig
⨍ Also includes the following purposes: VC,Rec,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig †	350	760	370	Irrig †	20	10	10	Irrig †	350	760	10
PS,WQ †	140	60	4	PS,WQ †	170	70	5	PS,WQ †	170	80	6
Pow**	250	430	610	Pow**	250	480	760	Pow**	260	540	880
Rur**	270	510	420	Rur**	150	250	360	Rur**	280	550	400
Pow,WQ	x	x	x	Pow	x	x	x	Pow,WQ	x	x	x
PS	36	88	120	PS	44	105	163	PS	46	108	180
←				WQ,VC	6.1	9.7	15.9				→
←				WQ,VC	0.34	0.54	0.88				→
WQ,VC	x	x	x					WQ,VC	x	x	x
WQ,VC	x	x	x					WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x								
WQ,VC	x	x	x					WQ,VC	x	x	x
←				HPG	x	x	x				→
FDR,VC	51	113	35	FDR,VC	x	1	1	FDR,VC	x	1	x
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	17	56	56	FDR	7	3	7	FDR	11	4	9
FDR,Drn,VC	1270	2530	2530	FDR,Drn,VC	80	70	330	FDR,Drn,VC	150	110	470
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
Nav	x	x	x	Nav	x	x	x	Nav	x	x	x

AREA 17

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	780	150	150
fee simple purchase (buying) (mi.)				
purchase lease (sq.mi.)	VC,FW	0	0	0
easements (sq.mi.)	VC, FW	150	150	150
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	17	6	55
Mainstream Flood Control Storage(1000af)	FDR	99	70	0

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	780	150	150	VC,FW	0	0	0	Same	as	EQ	
VC,FW	0	0	0	VC, FW	315	35	0	"	"	"	
VC, FW	150	150	150	VC, FW	150	150	150	"	"	"	
VC,FW	0	0	0	VC, FW	280	150	150	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x	x	x					WQ	x		
Pow		x	x								
				FW	x	x	x				
FW		x	x	Rec,FW	x	x	x	Rec,FW	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	74	222	222	FDR	17	6	51	FDR	25	8	88
FDR	81	70	0	FDR	81	70	0	FDR	99	70	0

AD-A036 617 CORPS OF ENGINEERS NEW YORK NORTH ATLANTIC DIV F/G 8/6
NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY. ANNEX 1.(U)
MAY 72

UNCLASSIFIED NL

4 OF 4
AD
A036617

END
DATE
FILMED
8-77

AREA 17

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	28*	15*	44*	
mainstream	33*	50*	152*	
wells	48*	40*	17*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	32	72	111	
industrial self-supplied water	1.3	2.7	4.4	
rural water supply	x	x	x	
irrigation, agriculture	8.9	4.4	4.6	
nonagriculture	14	13	17	
Power Plant Cooling Water	0	101	157	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial				
recreation	1.0	3.6	4.2	
Water Recreation	1110	620	1220	
Fish and Wildlife: fishing	3.6	4.9	6.0	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	680	1040	1690	
advanced	69	111	181	
other ‡				
Flood Damage Reduction: upstream	6.3	1.7	29.2	
mainstream	53	16	0	
Drainage Control	5.8	7.6	1.4	
Erosion Control	140	160	130	
Health	x	x	x	
Visual and Cultural	325	68	68	
Summation of Available Estimated Costs	2600	2300	3800	

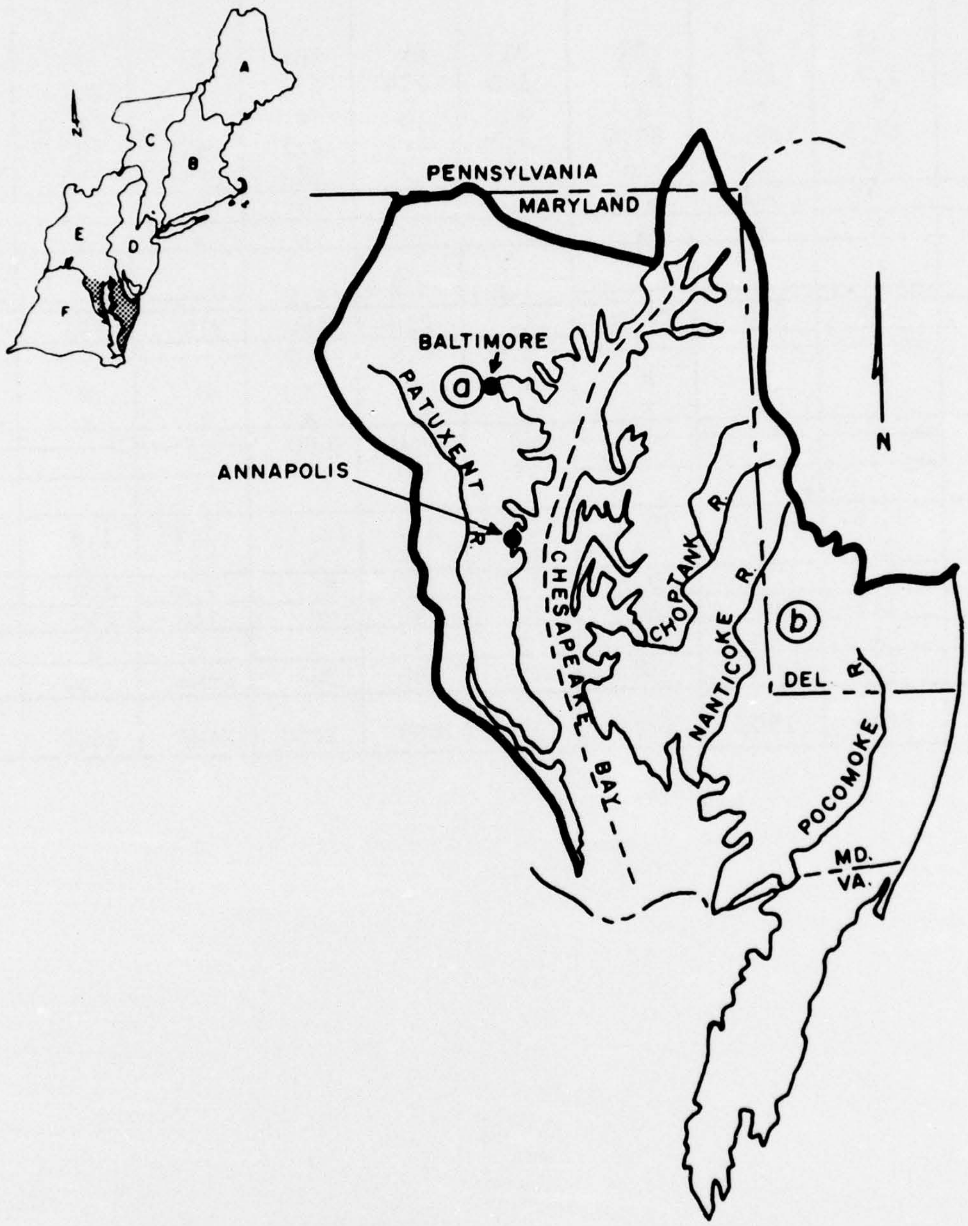
*From the supply model and includes OMR costs.

‡ Combined sewer overflows control and acid mine drainage control.

AREA 17

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	21	45	21	1.1	0.5	0.6	21	45	0.6
	37	17	2	42	21	3	43	21	4
	16	29	22	7	11	17	16	30	18
	27	58	80	31	69	101	32	72	111
	1.3	2.1	3.1	1.3	2.4	3.8	1.3	2.7	4.4
	x	x	x	x	x	x	x	x	x
	84.5	180.7	85.4	4.5	2.2	2.3	84.5	180.7	2.3
	15	13	16	14	13	17	15	13	16
	0	322	1070	0	0	0	0	63	175
	x	x	x	x	x	x	x	x	x
				1.0	3.6	4.2			
	1300	710	1460	210	210	450	910	530	980
				3.6	4.9	6.0			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				680	1040	1690			
				69	111	181			
	36.9	70.6	70.5	6.3	1.7	27.2	7.7	1.8	50.5
	27	16	0	27	16	0	53	16	0
	7.1	7.3	0.7	4.3	7.4	0.7	7.4	7.8	2.1
	140	160	130	50	90	90	140	160	130
	x	x	x	x	x	x	x	x	x
	325	68	68	197	46	30	Same	as	EQ
	2800	2900	4900	1300	1600	2600	2400	2400	3400

AREA 18 CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE



AREA 18

Chesapeake Bay and Delmarva Peninsula Drainages. Area 18 consists of the small drainage basins in Maryland, Virginia and Delaware and in a very small portion of Pennsylvania that flow into Chesapeake Bay or the Atlantic Ocean. The Area is divided into two sub-areas of which sub-area a has 2,705 square miles and includes the area drained by the Patuxent River and by the west shore of the Bay. Sub-area b has 5,440 square miles and includes most of the Delmarva Peninsula except for the northern half of the state of Delaware.

The area's topography is of low relief. Elevations in sub-area a range from sea level to the Piedmont with 500 to 800 foot elevations. Sub-area b ranges from sea level to 100 foot cliffs and slopes. The predominant land form is flat (over 60%) with the remainder being undulating land and rolling hills. The farm-forest land use pattern dominates with some farm, town-farm and city patterns. Chesapeake Bay provides major wintering grounds for migratory waterfowl and is essential to the North Atlantic Flyway. About two-thirds of the Area is of medial visual quality and one-third is of low visual quality.

Early settlement began along the Area's bays and rivers. The population was somewhat clustered near the water but agricultural development led to a more dispersed pattern than in the northern sections of the NAR. Exports consisted of forest products, timber, naval stores, grain and flour.

The 1960 Area population of 2.2 million is expected to nearly double by 2020. The Area's 1960 population density was 269 people per square mile. Sub-area a had 674 people per square mile while sub-area b had only 67. Baltimore is the Area's predominant population and transportation center.

Per capita income is expected to increase from 1.7% above the national average in 1959 to 4.0% above by 2020.

Employment is expected to increase from 0.8 million in 1960 to 1.8 million by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; transportation, communication and public utilities; and public administration. Employment is expected to decrease in agriculture, forestry and fisheries; mining; textile mill products; apparel and other textiles; lumber, wood products and furniture; and petroleum and coal products.

Fresh water is not abundant near the population centers of Area 18 and presently it is supplied from Area 17. Areas 17 and 18 are part of the hydrologic system of Chesapeake Bay and water moved from Area 17 to 18 are changes in outflow into the Bay. The waters adjacent to the Area's major population centers are degraded by municipal and industrial pollution.

Average annual runoff in Area 18 is approximately 5,500 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,225 m.g.d., and the corresponding seven-day minimum is about 76% of this total, or 935 m.g.d. (See Appendix C). The addition of 110 m.g.d. as an allowance for those consumptive losses not included and 40 m.g.d. developed for export to Area 19, results in an existing firm resource available for use of about 1,085 m.g.d., or 20% of the average runoff. This does not include allowance for transfer from Area 17.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,468 m.g.d., or 27% of the average runoff. Potential sources which would develop the increase of 383 m.g.d., include major storage, accounting for 58% of the increase, and ground water development, 42%.

Possible Alternative Planning Objectives. Each of the NAR planning objectives can be considered in Area 18, though the vast population differences could require different objective mixes for the sub-areas. The preservation and control of the unique natural resources along the shorelines and marshes of the Bay and the Atlantic Coast could be emphasized under both the Environmental Quality and Regional Development objectives to maintain the quality environment and to stimulate water recreation activities.

Some of the metropolitan and rural areas are underdeveloped and could be aided by Regional Development emphasis. Consideration can be given not only to the fact that the Area contains a heavily populated region but also to the proximity of other metropolitan regions and their social needs and problems. Water importation would probably be included in any objective mix, as would the Area's importance to migratory waterfowl.

Recommended Mixed Objectives. Separate mixed objectives are recommended for each of the states' portions of Area 18. Environmental Quality and Regional Development will receive equal emphasis in Maryland. This will work towards the preservation and development of the environmental and recreational resources of this portion of the Area, but in a manner that would make these resources available to all of the people, especially those with a low income.

The Delaware portion of the Area is given an Environmental Quality emphasis to preserve its landscapes diversity that includes rural, town, farm, forest and coastal units. The Atlantic Coastline of Delaware should receive particular attention to preserve its high environmental quality.

The Virginia portion of the Area emphasizes Regional Development because of the low income of the people. The Barrier Islands of Virginia, however, should have an Environmental Quality emphasis to preserve their uniqueness.

Needs to be Satisfied. Visual and cultural needs are very important in this Area as a result of its unique character. This Area contains about 50 percent of the total flat and marshland area in the NAR. Near term visual and cultural needs are very large and include: maintenance of unique shoreline landscape, landscape diversity and agricultural landscapes; and development of landscape quality.

Water quality maintenance needs are fairly large in the upper parts of the Chesapeake Bay. This key need is important for its far reaching effects in meeting water recreation, visual and cultural and fish and wildlife needs. Fish and waterfowl throughout the North Atlantic Region depend upon maintenance of the feeding, wintering and reproduction grounds of the Bay.

Flood damage reduction needs are also fairly high in the Area due mainly to tidal and upstream flooding. Inland flooding is accentuated on the Delmarva Peninsula by the water table being close to the surface. Commercial navigation needs will be high and grow at a moderate pace in all time periods. This is due to the increased emphasis upon industry in and around the port facilities of Baltimore. The fairly large recreational boating needs will increase as projected leisure time increases.

Satisfying the rapidly increasing fish and wildlife and water recreational needs is not only important to Area 18, but will alleviate some of the economic and social problems of nearby large metropolitan centers. Preservation of the Area's wetlands for the visual and cultural needs will be key to meeting fish and wildlife and water recreation needs and important for achieving the Area's mixed objective. Agricultural irrigation needs increase more rapidly in the early time periods where the need for maintaining the agriculture economy is most important. Forest and cropland drainage control needs are also very large for this same reason. Erosion control needs which are large and increase rapidly for coastlines, croplands and urban areas will assist economic development and help preserve landscapes.

The anticipated increases in population and industrial development will cause the water withdrawal needs of power plant cooling to be very large and industrial self-supplied water needs to be large with both needs experiencing a high growth rate. Brackish water needs for power plant cooling will be very large. Power development in Area 18 will constitute a large block of base load power for surrounding areas. There will be a large problem in resolving the conflict between the needs for power cooling water and fish and wildlife. Oysters, clams, crabs, menhaden, striped bass, waterfowl and many types of anadromous and other fish and wildlife depend upon the delicate ecological balance of the Bay.

Health needs include insect control - primarily of mosquitoes; the control of jelly fish to benefit recreational experiences; the control of pollution that affects shellfish in order to enhance the

economic climate of the Bay area; and monitoring of heavy metal disposal grounds so as to safeguard the public from tainted fish catches.

Publicly supplied water needs are fairly large in this Area but not critical to the mixed objective. Rural water supply needs are large and grow rapidly in this Area, as compared to other Areas, but will not be difficult to meet.

Devices. Land management controls and water quality control facilities are the most important devices employed to attain the mixed objectives. Land acquisition by means of fee simple purchase, purchase lease, zonings and easements should be stressed early in the planning period so as to safeguard unique shorelines and landscapes of the visual and cultural need. Meeting of visual and cultural needs depends upon the retention and maintenance of diverse and unique landscapes which will also help satisfy visual and cultural and some fish and wildlife and water recreation needs.

Meeting access needs through the use of land controls and facilities will be important to make maximum use of the extensive shoreline of the Area for public use. Water quality control devices would include water treatment facilities, and nutrient and storm water discharge control facilities. Fish and wildlife and water recreation needs will be especially dependent upon the use of water quality control facilities.

Publicly supplied water needs will require diverting fresh water from Area 17 before it reaches the upper Chesapeake Bay into the water-short Baltimore metropolitan area. Industrial self-supplied water needs will be satisfied primarily by wells and fresh and brackish intakes since present supplies are adequate for the projected needs. Navigation needs will be met by channel improvements which will be required to improve and foster industrial growth and economic income in the Bay area.

Water recreation needs will require a variety of devices such as land facilities, coastal shoreline erosion protection, and recreation boating facilities to provide for the recreation needs from nearby urban communities. Fish and wildlife needs will require reservoirs, land controls, habitat management and wildlife stocking.

There will be insufficient resources to meet all of Area 18's fish and wildlife needs. Some of the needs for stream fishing will be satisfied in contiguous areas.

The use of flood plain management for flood damage reduction can be used in conjunction with the land management devices for water recreation, fish and wildlife and visual and cultural needs. Upstream reservoirs will be needed for the last two planning periods for upstream flood damage reduction. Ocean projects for tidal and

hurricane flood damage reduction needs should be emphasized early to foster the growth of the coastal area. These projects should be carried out in a manner that is consistent with environmental quality.

Benefits. The benefits from meeting the needs of water recreation, visual and cultural, and fish and wildlife will be large and important to Area 18. Equally large and important will be the benefits that will accrue from meeting water quality maintenance needs. Meeting these needs will allow the orderly and progressive growth of land use patterns and their development along lines compatible with industrial expansion. Benefits from meeting water quality maintenance needs will be of many types and will increase the benefits from fulfillment of other needs including publicly supplied water, water recreation, health, and visual and cultural needs.

Transfering water into the Baltimore metropolitan service area (from Area 17) before it reaches the Upper Chesapeake Bay will provide important benefits by meeting publicly supplied water needs. This transfer will produce other benefits since the added supply will reduce costs for meeting the needs of industrial self-supplied water and non-agricultural irrigation water as well as produce health benefits.

The satisfaction of commercial navigation needs will result in large benefits to the Area's industrial activities, particularly to sub-area a, and will produce additional benefits from helping meet recreational boating needs.

Fulfillment of erosion and drainage control, irrigation and flood damage reduction needs will attain Regional Development benefits without restricting environmental quality. Power plant cooling, mostly with saline and brackish waters, will result in substantial benefits by providing a reliable base load supply to support the Area's growth.

Some benefits will result from meeting the needs of rural water supply and health, but their impact on Regional Development will be relatively small. These benefits will be key, however, in achieving the Environmental Quality aspect of the recommended mixed objective.

Costs. Early action costs for visual and cultural needs are extremely high and indicate the need to immediately establish protection for unique natural landscapes and shorelines. Water quality maintenance costs will be high in the first time period and increase substantially in each successive period as waste loads increase and as more advanced treatment becomes mandatory. This treatment will be to maintain the delicate ecological balance in the coastal areas and to protect the Bay's ability to provide a viable commercial fishery.

Commercial navigation needs will be costly to meet and will be highest in the first two time frames. These costs combined with those for recreational boating, will help produce the required impetus to sustain the Regional Development aspects of the mixed objective. Costs for publicly supplied water needs will be low to moderate in the initial planning period but will increase sharply during the second period and very greatly during the third period. This large cost increase is due primarily to the expected expansion of existing facilities as well as the installation of new facilities to transfer water to areas of need.

Costs associated with meeting flood damage reduction, water recreation, and irrigation needs will be moderate throughout the planning period. These costs will be consistent with the mixed objective in creating the climate for Regional Development and by fostering environmental values through investments in higher quality recreation and greater agricultural irrigation. Mainstream flood damage reduction costs are high in the first time period due to fulfilling tidal and hurricane needs. Irrigation costs will peak at the mid-time frame and then will drop drastically as the change to irrigation is completed. Erosion control costs will be fairly high throughout the planning period. Cropland drainage and agricultural erosion control costs will be highest in the first two time periods whereas streambank and coastal shoreline erosion control costs will be dominant in the last time period.

Power plant cooling costs and self-supplied industrial water costs will be low in the beginning of the study period and become moderate during the final phases. Environmental pressures coupled with high power plant cooling needs will create conflicts and high costs that can be reduced by the use of non-condensing devices. The need for adequate industrial self-supplied water for meeting the projected economic development of the Area will also require progressively higher investments and increasing use of brackish and waste water.

There will be additional costs in Area 18 due to the interaction of some devices. Erosion control and water recreation projects will conflict with visual and cultural needs; saline and brackish water withdrawals for power plants may affect fish and wildlife and water recreation needs; navigation devices will require increased use of water quality maintenance devices and will conflict with the fulfillment of fish and wildlife needs.

<u>Alternative Programs</u>. If Environmental Quality were chosen to be emphasized throughout Area 18, the needs of publicly supplied and industrial self-supplied water, and commercial navigation would

be lower. Power plant cooling needs would be changed as non-condenser facilities would not be used. Fresh water withdrawals and consumption would decrease. The use of brackish water withdrawals would increase in the first and decrease in the second and third time periods and brackish consumption would increase during the second and third periods. Saline water withdrawals would increase in the second and decrease in the third planning periods. Navigation aids would not be used during the first planning period. Upstream flood damage reduction would use more reservoirs in the early planning periods and the use of channel improvements and river projects would be sharply curtailed. Stabilization of the temperature and salinity patterns of Chesapeake Bay would be emphasized to an even greater extent. Agricultural irrigation needs and costs would be much larger to help meet visual and cultural needs for landscape.

If National Income were chosen, the needs of publicly supplied and industrial self-supplied water, agriculture irrigation, commercial navigation, water recreation and cropland drainage and erosion control would be reduced. Visual and cultural needs for development of quality landscape would be reduced. Less emphasis would be placed on public ownership or control of land which would increase zoning and/or tax incentive and reduce purchase leases and fee simple purchases. Non-condensing power facilities would not be used and power plant cooling needs would increase. The use of saline water withdrawal would decrease and fresh and brackish water withdrawals and consumption would increase. Upstream flood damage reduction would be achieved by less use of flood plain management, more watershed management and more channels in the last two planning periods.

If Regional Development were chosen, satisfaction of needs of forest drainage control and power plant cooling would be higher, while those of streambank and shoreline erosion would be lower. No non-condenser facilities would be used so that power plant cooling needs would be higher. Power plant cooling would rely on less ocean water withdrawal and more on brackish and fresh withdrawal and consumption. Forest drainage control, to increase productivity, would be augmented by additional investment. Flood damage reduction needs would emphasize more river projects in the first two planning periods while flood plain management would be reduced significantly in all years. Upstream reservoirs would be moved to the first planning period and watershed management moved to the first two benchmark years. High density water recreation would be encouraged to decrease costs and increase income. Agricultural irrigation would be increased along with costs to raise the competitiveness of the industry.

AREA 18

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	260	350	510	730
Industrial Self-Supplied Water (mgd)	160	310	620	1110
Rural Water Supply (mgd)	35	53	82	91
Irrigation Water: agriculture (1000 afy)	14	64	99	99
non-agriculture (1000 afy)	4	12	22	35
Power Plant Cooling: withdrawal, saline (cfs)	260	250	12300	32000
brackish (cfs)	2800	6900	11600	12400
fresh (cfs)	0	0	52	90
consumption, brackish (cfs)	30	80	100	110
fresh (cfs)	0	0	26	45
Hydroelectric Power Generation (mw)	1	0	0	0
Navigation: commercial (m. tons annually)	53	69	112	181
recreational boating (1000 boats)	90	110	210	280
Water Recreation: visitor days (m.)	x	11	18	33
stream or river (miles)	x	100	150	200
water surface (1000 acres)	x	19	28	39
beach (acres)	x	140	220	350
pool (m. sq. ft.)	x	2.5	3	5.9
land facilities (1000 acres)	x	11	16	24
Fish & Wildlife: sport fishing man-days (m.)	6.1	6.9	8.6	10.6
surface area, lake (acres)	x	27000	36000	48700
stream (acres)	x	0	1100	1100
access, fresh (acres)	x	270	400	540
salt (acres)	x	280	850	1540
anadromous (acres)	x	4	12	22
piers (1000 feet)	x	8	24	44
hunting man-days (m.)	1.7	2.0	2.2	2.7
access (1000 sq. mi.)	x	0.9	1.2	2.0
nature study man-days (m.)	2.8	3.2	3.9	4.9
access (1000 acres)	x	9	33	63
Water Quality Maint.: non-industrial (m. PEs)	2.2	2.8	3.4	4.3
industrial (m. PEs)	0.7	1.5	3.5	7.8
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	11	15	20	27
mainstream (m.$)	0.8	1.4	2.6	5.2
tidal & hurricane (m.$)	5	9	17	35
Drainage Control: cropland (1000 acres)	300	460	610	610
forest land (1000 acres)	x	0	12	47
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	370	710	970	1020
urban (1000 acres)	400	870	1160	1650
stream bank (mi.)	x	18	54	90
coastal shoreline (mi.)	x	88	198	239
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	x	350	350	350
unique shoreline (mi.)	x	350	350	350
high quality (sq.mi.)				
diversity (sq.mi.)	x	300	600	900
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)	x	200	400	600
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)	x	35	35	35

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	340	450	600	350	500	710	350	500	730
	300	550	880	300	590	1000	310	620	1110
				53	82	91			
	219	659	736	54	82	82	219	659	659
	14	23	34	11	21	34	12	22	34
	200	13300	26100	200	9000	23200	200	3600	14000
	8500	10300	9600	8500	12600	16900	8500	14800	17700
	0	0	40	0	130	300	0	300	750
	80	120	170	80	110	120	80	130	170
	0	0	27	0	57	106	0	117	264
				0	0	0			
	59	73	89	65	98	149	69	112	181
				110	210	280			
	11	18	33	10	16	29	12	19	33
	100	150	200	32	48	65	50	70	100
	19	28	39	5	8	11	10	15	21
	150	220	350	50	80	130	70	100	150
	2.5	3.7	5.9	1.0	1.5	2.5	1.3	1.9	3.0
	11	16	24	2	3	5	4	6	8
				6.9	8.6	10.6			
				27000	36000	48700			
				0	1100	1100			
				270	400	540			
				280	850	1540			
				4	12	22			
				8	24	44			
				2.0	2.2	2.7			
				0.9	1.2	2.0			
				3.2	3.9	4.9			
				9	33	63			
				2.8	3.4	4.3			
				1.5	3.5	7.8			
				15	20	27			
				1.4	2.6	5.2			
				9	17	35			
	460	610	610	400	550	550	460	610	610
	0	12	47	0	12	47	12	47	151
	710	970	1020	610	800	840	710	970	1020
	870	1160	1650	590	830	1220	870	1160	1650
	18	54	90	4	13	22	9	27	45
	88	198	239	4	14	24	10	31	52
	x	x	x	x	x	x	x	x	x
	350	350	350	350	350	350	Same	as	EQ
	350	350	350	350	350	350	Same	as	EQ
	300	600	900	300	600	900	Same	as	EQ
	200	400	600	100	200	300	Same	as	EQ
	35	35	35	35	35	35	Same	as	EQ

AREA 18

DEVICES-incremental	MIXED OBJECTIVE				
	Purposes	1980	2000	2020	
I. Resource Management					
A. Water					
Storage Facilities ϕ					
reservoirs, upstream (1000 af)	FW,Rec,VC	16*	251*	x*	
mainstream (1000 af)	FW,Rec,VC	x*	x*	x*	
Withdrawal Facilities					
intakes & pumping, fresh (mgd)	PS,Ind,Irrig	130	270	420	
brackish (mgd)	Ind	900	1870	2860	
estuarine (mgd)	Pow	x	x	x	
ocean (mgd)	Pow	x	x	x	
wells (mgd)		20*	150*	0*	
Conveyance Facilities					
interbasin diversions, into (mgd)		160*	40*	530*	
out of (mgd)					
Quality Control Facilities					
temperature, cooling towers & ponds	Pow,WQ	x	x	x	
chemical/biological					
potable water treat plants (mgd)	PS	4	9	59	
waste treatment plants					
secondary (85%) (m. PE removed)	WQ,VC,Rec	3.7	0	0	
secondary (90%) (m. PE removed)	WQ	0	6.3	10.9	
advanced (95%) (m. PE removed)	WQ	0	0	0.60	
effluent irrigation					
nutrient control	WQ,VC,Rec	x	x	x	
stormwater discharge control	WQ,VC,Rec	x	x	x	
acid mine drainage control					
septic tank control	WQ,VC,Rec	x	x	x	
separate combined sewers	WQ,VC,Rec	x	x	x	
Pumped Storage					
Desalting Facilities		0*	113*	86*	
Monitoring Facilities					
B. Water/Land					
Flood Plain Management					
upstream (1000 acres)	FDR,VC,Rec	470	770	x	
mainstream (1000 acres)	FDR,VC,Rec	x	x	x	
Local Flood Protection					
ocean (projects)	FDR	1	0	0	
river (projects)	FDR	17	16	0	
flood control channels (mi.)	FDR	730	430	0	
Watershed Management (1000 acres)	FDR,Drn,VC,Rec	370	490	0	
Erosion Protection, land treatment	Ern	x	x	x	
coastal shoreline	Ern	x	x	x	
river shoreline	Ern	x	x	x	
Drainage Practices	Drn	x	x	x	
Waterway Management					
navigation channel improvement	Nav	x	x		
debris removal					
recreation boating facilities	Rec,Nav	x	x	x	

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig,VC,FW	143	308	54	Irrig,VC,FW	28	20	x	Irrig,VC,FW	148	308	x
PS,VC,FW	4	6	x	PS,VC,FW	5	7	123	PS,VC,FW	5	8	123
Pow**	120	220	290	Pow**	120	240	350	Pow**	130	270	420
Ind	860	1510	1970	Ind	860	1690	2450	Ind	900	1870	2860
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	110	210	110	Rur**	70	110	120	Rur**	120	220	130
PS	0	0	130	PS	0	130	120	PS	0	130	120
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
PS	3	6	41	PS	3	8	57	PS	4	9	59
←				WQ,VC	3.7	0	0	→			
←				WQ	0	6.3	10.9	→			
←				WQ	0	0	0.60	→			
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
FDR,VC	620	1540	360	FDR,VC	80	x	20	FDR,VC	60	10	30
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	1	0	0	FDR	1	0	0	FDR	1	0	0
FDR	19	8	0	FDR	22	31	37	FDR	53	37	0
FDR	40	0	0	FDR	810	1140	1710	FDR	1950	1710	0
FDR,Drn,VC	490	990	990	FDR,Drn,VC	990	1390	1100	FDR,Drn,VC	1270	1100	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x		Nav	x	x	
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

DEVICES–incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW, Rec	330	150	150
fee simple purchase (buying) (mi.)	VC, FW, Rec	180	0	0
purchase lease (sq.mi.)	VC, FW, Rec	240	200	200
easements (sq.mi.)	VC, FW, Rec	150	150	150
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC, FW, Rec	180	0	0
zoning (mi.)	VC, FW, Rec	180	0	0
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW, Rec	x	x	x
site sanitation and utilities	VC, Rec	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish				
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research				
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000 af)	FDR	33	31	0
Waste Water (mgd)	Ind	150	380	820
Protect Shellfish	Hlth	x	x	x
Protection from Jellyfish	Hlth,Rec	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	740	350	350	VC, FW	180	0	0	Same	as	EQ	
VC, FW	350	0	0	VC, FW	180	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	140	100	100	"	"	"	
VC,FW	150	150	150	VC,FW	150	150	150	"	"	"	
VC,FW	0	0	0	VC,FW	180	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	180	0	0	"	"	"	
VC,FW	0	0	0	VC,FW	150	150	150	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x					Rec	x	x	x
				FW, Rec	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
Pow		x	x								
FW,Rec	x	x	x	FW,Rec	x	x	x	FW,Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	148	6	0	FDR	44	61	43	FDR	105	43	0
Ind	140	310	600	Ind	140	340	720	Ind	150	380	820

AREA 18

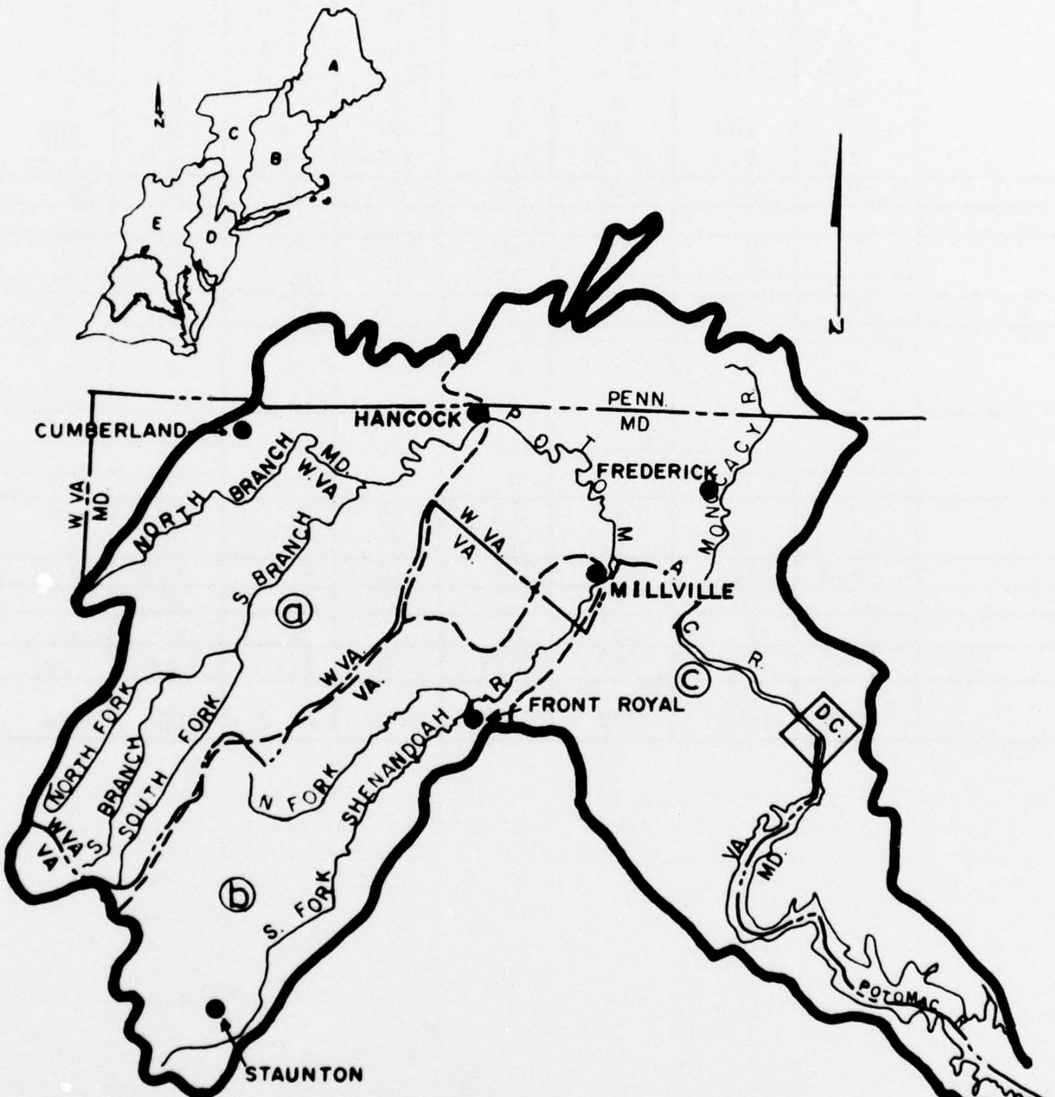
FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	2.7*	36.8*	0*	
mainstream	0*	0*	0*	
wells	6.6*	20.2*	0*	
desalting	0*	204.6*	132*	
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	1.7*	30.4	193.8*	
public water supply	4.0	6.7	17.6	
industrial self-supplied water	6.4	13.5	22.1	
rural water supply	x	x	x	
irrigation, agriculture	10	11	0	
nonagriculture	5.9	6.8	8.8	
Power Plant Cooling Water	0	0	15	
Hydroelectric Power Generation				
Navigation: commercial	120	150	0	
recreation	12	14	16	
Water Recreation	54	30	42	
Fish and Wildlife: fishing	4.7	4.0	4.4	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	410	670	1150	
advanced	0	0	120	
other ≠				
Flood Damage Reduction: upstream	9	8	0	
mainstream	45	0	0	
Drainage Control	9.5	9.9	1.1	
Erosion Control	131	113	97	
Health	x	x	x	
Visual and Cultural	1510	140	140	
Summation of Available Estimated Costs	2300	1500	2000	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	11.6	26.1	4.4	2.0	2.2	0	11.6	26.1	0
	2.1	2.1	0	2.5	2.8	23.4	2.5	2.9	23.4
	8.5	15.9	8.0	4.2	6.3	7.7	8.5	16.9	8.3
	0	0	0	0	0	0	0	0	0
	0	0	3.0	0	3.0	45.0	0	3.0	45.0
	3.5	5.3	13.9	4.0	6.7	17.1	4.0	6.7	17.6
	6.0	11.0	15.4	6.0	12.3	22.0	6.4	13.5	22.1
	x	x	x	x	x	x	x	x	x
	47	105	18	8	9	0	47	105	0
	6.5	6.4	7.8	5.7	6.5	8.4	5.9	6.6	8.1
	0	43	232	0	0	0	0	39	133
	0	0	0	120	150	0	120	150	0
	←			12	14	16			→
	54	30	42	17	8	11	26	12	19
	←			4.7	4.0	4.4			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			410	670	1150			→
	←			0	0	120			→
	13	1	0	13	16	21	29	21	0
	45	0	0	45	0	0	45	0	0
	9.5	9.9	1.1	5.7	9.9	1.1	9.9	10.7	3.3
	131	113	97	42	51	66	96	72	87
	x	x	x	x	x	x	x	x	x
	2880	140	140	1430	60	60	Same	as	EQ
	3600	1200	1900	2100	1000	1600	3700	1300	1800

AREA 19 POTOMAC RIVER BASIN



AREA 19

Potomac River Basin. Area 19 consists of the District of Columbia and the portions of West Virginia, Virginia, Pennsylvania and Maryland drained by the Potomac River basin. Sub-area a comprises the 4,073 square mile drainage of the upper portion of the Potomac River above Hancock, Maryland, including the North and South Branches. Sub-area b contains the 3,040 square mile drainage of the Shenandoah River above Millville, West Virginia and includes the North and South forks. Sub-area c covers over half of the Area - 7,557 square miles - including the lower mainstem of the Potomac River below Hancock, Maryland and all of the Monocacy River drainage.

The Area's topography differs in each of the sub-areas. Sub-area a contains heavily forested mountains and rolling foothills. Sub-area b is characterized by an alternating band of ridges and rich fertile valleys, including Shenandoah National Park. Sub-area c is a gentle coastal plain and includes Washington, D. C. which is by far the dominant metropolitan center in the Area particularly because of its political and national importance.

Area 19 is very diverse in land form with nearly equal amounts of steep hills, rolling hills, undulating land and composite forms, and a small section of mountains. Its pattern is diverse also with over 75 percent in either farm or forest-wildland and smaller amounts of farm-forest, forest-town and city. The visual quality for two-thirds of the Area is medial and one-third is low. Of great importance, however, are the many miles of free flowing streams and the clusters of historic sites throughout the Area. These many diverse characteristics are all readily accessible from the Washington, D. C., metropolitan area.

The Area's 1960 population was 2.97 million with the vast majority - 2.6 million - located in sub-area c. The population density of the Area was 202 people per square mile while there were 346 people per square mile in sub-area c. There were 160 thousand people in sub-area a with a density of 39 people per square mile. Sub-area b had 197 thousand people and a density of 65 people per square mile.

Per capita income was 9.6% above the national average in 1959 and is expected to increase to 10.6% above by 2020.

The Area's 1960 employment was 1.2 million and is expected to increase to 3.7 million by 2020. Industries with the largest 1960 employment include services; public administration; wholesale and retail trade; contract construction; and transportation, communication and public utilities. Employment is expected to decrease in agriculture, forestry and fisheries, and textile mill products.

Water is generally available in the Area. Large industrial and municipal waste discharges degrade water quality in the upper Potomac River estuary below metropolitan Washington, D.C. Acid mine drainage and municipal and industrial pollution also lower the quality along the North Branch of the Potomac River.

Average annual runoff in Area 19 is approximately 8,970 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 1,110 m.g.d., and the corresponding seven-day minimum is about 60% of this total or 670 m.g.d. (See Appendix C). The addition of 106 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of about 776 m.g.d., or 9% of the average runoff. This does not include an import of about 40 m.g.d. from Area 18.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 3,552 m.g.d., or 40% of the average runoff. Potential sources which would develop the increase of 2,776 m.g.d., include major storage, accounting for 50% of the increase; upstream storage, 17%, and ground water development, 33%.

Possible Alternative Planning Objectives. All three of the NAR planning objectives can be considered in Area 19. The sub-areas vary considerably in topography, population, water quality and per capita income, among other characteristics, and may require several different objective mixes for different portions of the Area. Environmental Quality can be emphasized to preserve and protect the quality natural landscapes and the undeveloped sections, and to restore water quality in the degraded regions. Regional Development can be emphasized over-all to encourage increased industrial development and to raise the per capita income levels of depressed areas such as the Appalachia regions of West Virginia and Maryland. The Area's present level of growth rate could be allowed to continue under a mixed objective emphasizing National Income.

Recommended Mixed Objective. It is recommended that National Income receive primary emphasis in Area 19 augmented by overtones of Environmental Quality with pockets of Regional Development. In the upper Shenandoah River portions of Virginia and along the mainstem of the Potomac in sub-area c the present reasonable rate of growth and development should be allowed to continue. The Appalachian portions of West Virginia and Western Maryland should receive Regional Development emphasis to raise the per capita income levels. Environmental Quality should be emphasized along the mainstem of the Shenandoah River, where little industrial development is anticipated, and in sections of West Virginia where erosion and acid mine drainage have been degrading water quality. Environmental Quality should also be emphasized in the Washington, D. C., metropolitan area in support of the primary National In-

come objective. In the Pennsylvania portion of the Area the primary objective should be Environmental Quality with some Regional Development.

Needs to be Satisfied. The need for publicly supplied water is fairly large and rapidly growing in Area 19. This important need, however, is highly concentrated in Sub-area c, while the water resources are fairly evenly distributed over the whole Area. The industrial self-supplied water needs will also be large. Rural water supply needs will be very large in comparison to other Areas, and will grow steadily during the early time frames.

Satisfying the fairly large and rapidly growing water quality maintenance needs will be the key to withdrawal needs such as water supply, as well as the needs of water recreation, fish and wildlife and visual and cultural. Water quality maintenance is especially important to the ecological balance in Chesapeake Bay, and fulfillment of all types of fish and wildlife needs.

The needs for agricultural and urban erosion control are large, grow fast and when fulfilled, also raise the quality of water in the Area. The fulfillment of these needs will be important to the Area's mixed objective. Fish and wildlife needs are large and along with the water recreation needs will increase rapidly because of the increasing burden the large nearby population will be placing on existing facilities.

The large environmental quality potential of the Area requires that particular emphasis be placed on the important and key visual and cultural needs. These will be very large and include the maintenance of unique shoreline, and agricultural landscapes as well as the maintenance of landscape diversity. This is primarily due to the large quantity of historical and unique natural sites and diverse and farm landscapes close to large population centers of the Area. Visual and cultural need fulfillment will help satisfy water recreation and health needs of the Area.

Power plant cooling needs for fresh and brackish water will be large to provide for the projected population and industrial growth. Hydroelectric power generation needs are not large but grow rapidly for the same reasons. Needs for irrigation water are large but agricultural need decreases in the last planning period. Cropland drainage control need is large and forest land drainage control will grow rapidly. These needs will insure the continued competitiveness of agriculture in Area 19 with agriculture in nearby areas and help retain landscape diversity. Erosion control needs of all types will be very large in this Area and increase rapidly.

Flood damage reduction needs are large and will grow rapidly over the planning period because of the high degree of urban-

ization expected along the waterways. There will be proportionally fewer needs for upstream flood damage reduction in the Maryland portion of the Area.

Devices. Publicly supplied water needs will depend on reservoirs along with the appropriate distribution devices that include aqueducts, channels and pumping. These reservoirs will also be used to help satisfy the needs of fish and wildlife, agricultural irrigation, water recreation and flood damage reduction. Reservoir water for withdrawal needs will be supplemented by wells and river intakes. Reservoirs will be supplemented by estuarine intakes for power plant cooling and by river intakes for agriculture irrigation needs. Cooling facilities and noncondensing facilities will be used to reduce withdrawal requirements in the interest of environmental quality, particularly in the later time periods.

Water quality maintenance needs will be met by the important water quality control facilities that include combinations of waste treatment plants, nutrient control, thermal and stormwater discharge control, acid mine drainage control and separation of combined sewers.

Flood plain and watershed management and storage devices will fulfill the flood damage reduction needs and some of the visual and cultural needs with minimum use of local protection projects. All of the biological and some land control devices will be necessary to meet the fish and wildlife and visual and cultural needs. The land control devices are fee simple purchase, purchase lease, and easements.

Waterways management devices will meet commercial navigation and recreational boating needs. These devices include navigation channel improvements in the last two planning periods and recreational boating facilities in all years.

Benefits. Benefits from fulfillment of all water withdrawal needs should be large in Area 19 because of the expected industrial and population growth. Reservoir storage, all water intakes and conveyance facilities will provide most of these benefits. The benefits from meeting these needs will be larger because of the multiple use of the reservoirs. Benefits will also be larger from the publicly supplied and industrial self-supplied water, visual and cultural, and fish and wildlife needs because of the use of ocean and estuarine intakes for power plant cooling needs and from fulfilling water quality maintenance needs.

Recreation and visual and cultural benefits will be high. These benefits will arise because recreation facilities and cultural sites that are close to large urban populations will be utilized to a maximum.

Benefits to flood damage reduction will be fairly high because of the heavy damages that presently occur. Flood plain management and planning of urban patterns will provide multiple use benefits by adding to fulfillment of visual and cultural needs.

Policy changes in Area 19 will provide large benefits for environmental quality. Such changes will reduce the need for storage facilities and increase retention of more natural waterways. This will be difficult, however, because of the large water withdrawal and surface water needs in the Area. The use of non-condensing power facilities to meet the Area's power generation needs and of water re-use for industrial needs will be of particular benefit in the maintenance of the environmental quality.

Costs. The most costly need in the Area is water quality maintenance which is a result of the magnitude of the projected pollution loading and of the high degree of treatment that would be required. Standards may still be hard to achieve because of amount and type of effluent loads to be treated.

Publicly supplied water costs will be fairly high in the last two planning periods because of the large investments needed either for reservoirs or for special facilities permitting larger re-use of estuarine water. High recreation costs will be incurred, especially near the urban areas, as new water surfaces and pertinent facilities are provided along with the conversion of existing sites and projects for recreational use.

Visual and cultural needs will be very costly in the initial planning period because of the quantity of land and quality of cultural sites involved and also because of the degree of settlement throughout the Area. Purchases must be made in the first time frame so that unique and diverse landscapes will not be lost to development. Water recreation costs will also be high because of the size of the need and to satisfy the desire for high quality experiences.

Flood damage reduction costs will be moderate in the first two planning periods for upstream reservoirs. Erosion control costs will be fairly large but decrease in the last time period.

Alternative Programs. If Environmental Quality were chosen to be primarily emphasized throughout Area 19, the need for cropland drainage control would be slightly increased and the need for agricultural irrigation would be greatly increased; a different emphasis would be placed on flood damage reduction and navigation devices. Increasing cropland drainage control and irrigation water needs would increase crop yields which, in turn, would help maintain the existence of farms and diversified landscapes. Publicly supplied water, and industrial self-supplied water needs would be slightly lower because of lower population and industrial projections. The need for upstream flood damage reduction would be met by more up-

stream reservoirs in the first period and river projects in the first two planning periods along with more watershed management in the last two planning periods. The needs for commercial navigation would be reduced. Emphasis would be given to development of recreational boating facilities. Power plant cooling needs would change in the last two planning periods by increases in brackish water and decreases in saline and fresh water withdrawals. Consumption of brackish water would increase and fresh water consumption would decrease in all planning periods.

If Regional Development were emphasized, agriculture irrigation would be significantly increased in all planning periods, so as to increase the Area's economic income from farming. Power plant cooling needs for brackish water withdrawal and consumption would be larger in the last two planning periods as non-condenser facilities would not be used. Water withdrawals and consumption would decrease for fresh and saline waters. Cropland and forest drainage control and agriculture irrigation needs would be increased. Streambank and shoreline erosion control needs, however, would be greatly reduced where it would not interfere with development. Use would be made of recreational boating facilities. Water recreation needs and costs would decrease, except the need for visitor days, to increase the economic return to the Area from these activities. The needs for publicly supplied and industrial self-supplied water would show slight increases. The combined increases in water withdrawal needs may be so great that, by the last planning period, the practical limit of development would be exceeded and inter-basin transfers would be required. The devices for flood damage reduction would be changed to aid in growth of local industry. There would be less use of flood plain management and more use of watershed management and river projects for upstream flood damage reduction in the first planning period.

If National Income were chosen to be primarily emphasized the changes from the recommended program would primarily be in devices. No non-condensing facilities would be used to eliminate the extra costs of energy production. Brackish and freshwater withdrawals would increase along with brackish consumption. Saline withdrawals and fresh consumption would decrease. Water recreation needs of all types would be reduced in all time periods. Upstream flood damage reduction would be achieved by less flood plain management. All of the erosion control needs would be much smaller since environmental quality would not be emphasized. The visual and cultural needs for metropolitan amenities would occur in the second planning period, and less fee simple purchase, purchase leaseback and easements and more zoning and/or tax incentives would be used to reduce costs.

AREA 19

NEEDS-cumulative	Pres.	MIXED OBJECTIVE		
		1980	2000	2020
Publicly Supplied Water (mgd)	360	540	900	1440
Industrial Self-Supplied Water (mgd)	270	520	910	1400
Rural Water Supply (mgd)	50	80	120	120
Irrigation Water: agriculture (1000 afy)	8	39	55	49
non-agriculture (1000 afy)	6	21	36	56
Power Plant Cooling: withdrawal, saline (cfs)	0	0	4000	12000
brackish (cfs)	1600	2600	1500	2300
fresh (cfs)	910	820	2960	3370
consumption, brackish (cfs)	15	14	12	20
fresh (cfs)	27	41	88	150
Hydroelectric Power Generation (mw)	13	10	1000	4000
Navigation: commercial (m. tons annually)	3.5	3.8	5.3	8.0
recreational boating (1000 boats)	84	94	163	220
Water Recreation: visitor days (m.)	x	33	59	109
stream or river (miles)	x	230	280	570
water surface (1000 acres)	x	43	71	119
beach (acres)	x	340	560	900
pool (m. sq. ft.)	x	5.9	9.6	15.5
land facilities (1000 acres)	x	24	41	66
Fish & Wildlife: sport fishing man-days (m.)	7.5	9.5	13.6	18.6
surface area, lake (acres)	x	36000	56000	84000
stream (acres)	x	6900	6900	6900
access, fresh (acres)	x	490	870	1330
salt (acres)	x	580	1750	3160
anadromous (acres)	x	62	90	126
piers (1000 feet)	x	17	50	90
hunting man-days (m.)	3.9	4.4	6.3	8.6
access (1000 sq. mi.)	x	0.2	1.6	2.4
nature study man-days (m.)	4.4	5.6	8.1	11.1
access (1000 acres)	x	16	52	97
Water Quality Maint.: non-industrial (m. PEs)	2.1	4.4	6.3	8.6
industrial (m. PEs)	0.8	2.0	5.1	10.7
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	7	11	20	40
mainstream (m.$)	6	13	27	60
tidal & hurricane (m.$)				
Drainage Control: cropland (1000 acres)	110	140	190	190
forest land (1000 acres)	x	0	5	19
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	2500	3300	4000	4100
urban (1000 acres)	540	880	1320	1840
stream bank (mi.)	x	100	280	480
coastal shoreline (mi.)	x	24	49	51
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	x	1000	1000	1000
unique shoreline (mi.)	x	90	90	90
high quality (sq.mi.)				
diversity (sq.mi.)	x	400	800	1200
agriculture (sq.mi.)	x	2000	2000	2000
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)		40	40	40

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
520	820	1210	540	900	1440	550	920	1490
520	870	1250	520	910	1400	540	980	1560
			80	120	120			
228	672	841	39	55	49	228	672	666
24	39	56	21	36	56	22	37	56
0	1000	4000	0	1000	6000	0	2000	7000
2500	2500	3500	2500	5500	8600	2500	4500	7600
920	110	70	920	4500	8000	920	2300	2750
22	60	110	22	45	74	22	50	120
33	42	32	33	63	101	33	83	110
			10	1000	4000			
3.6	4.4	5.9	3.8	5.3	8.0	3.9	5.8	9.1
			94	163	220			
33	59	109	29	51	95	34	60	111
230	280	570	80	90	190	110	140	280
43	71	119	12	20	30	23	37	58
340	560	900	130	210	330	160	260	400
5.9	9.6	15.5	2.5	4.0	6.5	3.1	5.0	7.9
24	41	66	5	8	12	9	15	23
			9.5	13.6	18.6			
			36000	56000	84000			
			6900	6900	6900			
			490	870	1330			
			580	1750	3160			
			62	90	126			
			17	50	90			
			4.4	6.3	8.6			
			0.2	1.6	2.4			
			5.6	8.1	11.1			
			16	52	97			
			4.4	6.3	8.6			
			2.0	5.1	10.7			
			11	20	40			
			13	27	60			
160	220	220	140	190	190	160	220	220
0	5	19	0	5	19	5	19	61
3300	4000	4100	2900	3200	3300	3300	4000	4100
880	1320	1840	650	840	1150	880	1320	1840
100	280	480	20	70	120	50	140	240
24	49	51	1	2	3	1	1	2
x	x	x	x	x	x	x	x	x
1000	1000	1000	1000	1000	1000	Same	as	EQ
90	90	90	90	90	90	Same	as	EQ
400	800	1200	400	800	1200	Same	as	EQ
2000	2000	2000	2000	2000	2000	Same	as	EQ
40	40	40	20	40	40	Same	as	EQ

AREA 19

DEVICES–incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec,VC	35*	32*	4*
mainstream (1000 af)	FW,Rec,VC,WQ	80*	230*	370*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	300	510	660
brackish (mgd)	Ind	12	19	25
estuarine (mgd)	Pow	x	x	x
ocean (mgd)	Pow		x	x
wells (mgd)		190*	50*	120*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	120	350	570
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	5.8	10.3	17.4
advanced (95%) (m. PE removed)	WQ,VC	0.32	0.57	0.97
effluent irrigation	Irrig	x	x	x
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control	WQ,VC	x	x	x
septic tank control				
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG		x	x
Desalting Facilities				
Monitoring Facilities	WQ,VC	x	x	x
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	97	253	62
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	18	19	0
flood control channels (mi.)				
Watershed Management (1000 acres)	FDR,Drn,VC	1490	240	x
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.
** Also includes the following purposes: PS,Ind,Irrig
ϕ Also includes the following purposes: VC,Rec,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig ≁	176	355	134	Irrig ≁	25	13	x	Irrig ≁	176	355	x
PS,WQ ≁	20	200	250	PS,WQ ≁	20	240	350	PS,WQ ≁	20	250	370
Pow**	290	450	500	Pow**	300	510	660	Pow**	320	570	760
Ind	12	15	20	Ind	12	19	25	Ind	13	18	34
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Pow		x	x	Pow		x	x	Pow		x	x
Rur**	120	180	100	Rur**	80	110	210	Rur**	120	190	100
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
PS	110	290	410	PS	120	350	570	PS	130	370	600
				WQ,VC	5.8	10.3	17.4				
				WQ,VC	0.32	0.57	0.97				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
				HPG		x	x				
FDR,VC	97	253	62	FDR,VC	11	5	32	FDR,VC	9	7	16
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	37	31	0	FDR	18	19	0	FDR	31	6	0
FDR,Drn,VC	900	1810	1810	FDR,Drn,VC	1490	240	x	FDR,Drn,VC	2490	180	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x	x	Nav	x	x	
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 19

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	1090	0	0
fee simple purchase (buying) (mi.)	VC, FW	90	0	0
purchase lease (sq.mi.)	VC, FW	2000	0	0
easements (sq.mi.)	VC,FW	350	400	400
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)	VC,FW	0	0	0
zoning (mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs.(sq.mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)	Ind		x	x
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	210	200	0
Mainstream Flood Control Storage(1000af)	FDR	36	90	465
Ground Water Storage for Low Flow Augmentation	Ind	x	x	x
Strip Mine Reclamation	VC	x	x	x
Phosphorus and Nitrogen Removal	WQ	x	x	x
Technology Change	Ind	x	x	x

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	1090	0	0	VC, FW	500	0	0	Same	as	EQ	
VC, FW	90	0	0	VC, FW	45	0	0	"	"	"	
VC, FW	2000	0	0	VC, FW	1020	20	0	"	"	"	
VC,FW	350	400	400	VC,FW	350	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	200	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	45	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	1400	400	400	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
←				FW	x	x	x	→			
VC	x	x	x	VC	x	x	x	Same	as	EQ	
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				Hlth	x	x	x	→			
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
Pow		x	x								
←				FW	x	x	x	→			
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	410	20	0	FDR	210	200	0	FDR	350	60	0
FDR	36	x	5	FDR	36	90	465	FDR	36	90	465

AREA 19

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE			
	1980	2000	2020	
Water Development Costs:				
storage, upstream	14.0*	13.4*	1.9*	
mainstream	53*	46*	101*	
wells	29.8*	15.3*	16.7*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	100	210	310	
industrial self-supplied water	1.30	2.08	2.65	
rural water supply	x	x	x	
irrigation, agriculture	5.5	4.0	0	
nonagriculture	12	11	15	
Power Plant Cooling Water	0	24	70	
Hydroelectric Power Generation		x	x	
Navigation: commercial				
recreation	14	18	20	
Water Recreation	129	174	279	
Fish and Wildlife: fishing	10	10	12	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	650	1090	1850	
advanced	66	117	198	
other ≠				
Flood Damage Reduction: upstream	29	35	0	
mainstream	20	7	36	
Drainage Control	2.88	5.08	0.63	
Erosion Control	131	126	90	
Health	x	x	x	
Visual and Cultural	1264	97	97	
Summation of Available Estimated Costs	2500	2000	3100	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	14.0	28.6	10.6	1.6	1.1	0	14.0	28.6	0
	16	96	88	18	115	123	19	120	129
	7.5	11.6	8.0	4.2	5.0	6.7	7.5	12.2	6.9
	90	190	230	100	210	310	100	230	320
	1.30	1.85	2.03	1.30	2.08	2.65	1.39	2.32	3.14
	x	x	x	x	x	x	x	x	x
	49.4	101.0	37.5	5.5	4.0	0	49.4	101.0	0
	13	11	14	12	11	15	12	11	14
	0	144	256	0	0	0	0	44	160
		x	x		x	x		x	x
				14	18	20			
	129	174	279	6	27	95	9	67	140
				10	10	12			
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
				650	1090	1850			
				66	117	198			
	64	0	0	29	35	0	58	7	0
	20	5	0.4	20	7	36	20	7	36
	4.85	4.99	0.63	2.88	5.08	0.63	5.08	5.39	1.89
	131	126	90	38	48	54	119	112	86
	x	x	x	x	x	x	x	x	x
	1264	97	97	668	12	0	Same	as	EQ
	2500	2500	3200	1700	1700	2700	2400	2100	3100

AREA 20 RAPPAHANNOCK AND YORK RIVER BASINS

AREA 20

Rappahannock and York River Basins. Area 20 is located completely within the State of Virginia and covers 6,000 square miles. The Area consists of the drainages into Chesapeake Bay from Smith Point to Old Point Comfort. The uppermost of the two sub-areas, sub-area a covers 2700 square miles and includes the Rappahannock River Basin and its adjacent coastal drainage. Sub-area b covers 3300 square miles and includes the York River Basin and the remainder of the coastal drainage.

All five cultural landscapes are represented in the Area with farm-forest predominating and a lesser amount of farm and forest-wildland units. Nearly three-fourths of this Area is indulating land, about one-fourth is rolling hills, and small amounts are mountains and steep hills. These landscapes range from the Piedmont Plateaus, mountains and valleys to the coastal plain, a low area intersected by deltas of rivers and creeks flowing into the Chesapeake Bay. Sloping lowlands, tidal rivers, marshes and swamplands are prevalent in the low areas. The overall visual quality of the Area is medial, 75 percent, and the remaining is low. There is a scientifically unique wildlife habitat of about 1500 square miles around the mouth of the Rappahannock.

The large tracts of fertile land and an amiable climate attracted early settlement of the Area. The major crops developed were grain and tobacco, while the extensive forest resources provided lumber, naval stores and potash. There were only minor amounts of industrial development.

The population of the Area in 1960 was 310,000 for a population density of 51 per square mile. More than two-thirds of the population lived in sub-area b where the population density was 64 per square mile, while the density of sub-area a was 33. The projected population for 2020 is 740,000 or 123 per square mile.

Per capita income was 25 percent below the national average in 1959, but it is projected to increase to one per cent below the national average by 1980 and slowly increase to equal that average by 2020.

The 1960 employment totaled 120,000 and this figure is expected to double by 2020. Industries with the largest 1960 employment include services; wholesale and retail trade; forestry and fisheries; and public administration. Employment is expected to decrease in agriculture, forestry and fisheries; food and kindred products; and lumber, wood products and furniture.

Water is generally abundant in the Area, but, flows are extremely variable and the minimum flows are unusually low. The only major water quality problem in the Area is on the Rappahannock River below Fredericksburg due to the discharge of partially treated municipal and industrial wastes.

Average annual runoff in Area 20 is approximately 3,680 m.g.d. The existing minimum monthly flow (shortage index 0.01) is 130 m.g.d., and the corresponding seven-day minimum is about 50% of this total, or 65 m.g.d. (See Appendix C). The addition of 13 m.g.d. as an allowance for consumptive losses results in an existing firm resource available for use of 78 m.g.d., or 2% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 1,702 m.g.d., or 46% of the average runoff. Potential sources which would develop the increase of 1,624 m.g.d., include major storage, accounting for 52% of the increase; upstream storage, 32%, and ground water development. 16%.

Possible Alternative Planning Objectives. All three NAR planning objectives can be considered for separate emphasis in Area 20. There are portions of the Area with low per capita income that could be aided by an emphasis upon Regional Development. The various land, transportation and power resources of the Area would be used along with investments in water resources to improve the economy. The Area also have a diversified natural landscape and makes significant contributions to the ecological balance of the lower Chesapeake Bay. An Environmental Quality emphasis would help the development and maintenance of these resources. The present economic growth trends could be maintained by a National Income emphasis. This emphasis would also increase the Area's contribution of goods and services for the nearby Washington, D. C. metropolitan area.

Recommended Mixed Objective. It is recommended that Environmental Quality be given primary emphasis in Area 20's planning objective, with some attention given to National Income. The overall economic improvement of the Area will depend on meeting the growing needs for goods and services in the Washington, D.C., metropolitan area, which will be best accomplished by continuing the present growth trends in that portion of the Area under a National Income objective. Environmental Quality should receive special attention because of the Area's high quality natural resources within easy access to the Washington populace and to protect the fish and wildlife resources of the Chesapeake Bay.

Needs to be Satisfied. Industrial self-supplied needs will be important especially to help the Area's industry grow in the second and third time periods. Rural water supply needs will be fairly large on a percapita basis and along with publicly supplied water needs will be important and grow fairly rapidly as they parallel population increases throughout the planning period. Non-agricultural irrigation needs will grow very rapidly as recreation increases in the Area.

Agriculture irrigation needs will increase slowly. Power plant cooling withdrawal needs for saline water will have very large increases to meet industrial and population energy needs.

Water recreation and fish and wildlife needs will grow rapidly and be important, not only to Area 20, but also to meet the needs of adjacent urbanized Areas. Tidal flood damage reduction needs will grow rapidly and navigation needs will have a much slower but steady growth rate; both will remain relatively small. Agricultural erosion and forest drainage control needs will be large but only the latter will have a high growth rate. Coastal and stream bank erosion control needs will not be large but will grow rapidly throughout the planning period.

Water quality maintenance and health needs are fairly small but have to be met in the industrial and urbanized sectors to achieve the Area's mixed objective. Water quality maintenance will be important to fish and wildlife needs and the continued ecological balance of Chesapeake Bay. In the early time frames the Area has a large power plant cooling need for fresh water consumption on a per capita basis. This is due to the Area's ability to support the regional power market. There will be large visual and cultural needs for the maintenance of diverse landscapes such as the marshlands near river mouths. Those and the other visual and cultural needs will be large because of the expanding adjacent urban areas.

Devices. Storage facilities along with wells, river and lake intakes, pipelines and pumping stations will satisfy the publicly supplied, industrial self-supplied and irrigation water needs. The storage reservoirs will also help satisfy the instream needs of water recreation and fish and wildlife and the needs of water quality maintenance and flood damage reduction. Advanced waste treatment will be required in the Area's upper reaches. The quality of the water in the lower reaches may be good enough that water quality standards can be met solely by dilution (low flow augmentation). Power plant cooling needs will be met by saline and fresh water withdrawals that will be supplemented by cooling towers to protect against thermal pollution. The environmental quality of each power plant site must be maintained.

Fish and wildlife needs will be met by utilizing the land control devices of fee simple purchase, easements, zoning and parking and trails in addition to the biological devices of habitat management, stocking and water quality standards enforcement. The land controls and facilities augmented by water quality control and flood plain and watershed management devices will meet the visual and cultural needs. These management devices plus upstream flood control channels, river projects and upstream reservoirs will be used to meet flood damage reduction needs. Navigation channel improvements and recreation boating facilities will meet recreational boating needs. Reservoirs along with overland transportation, addition of new project needs and change of

project design loads will meet water recreation needs. Health needs will be met by implementing insect control.

Benefits. Satisfying publicly supplied and industrial water needs will yield large benefits to the Area since the expanding population and industry require water to insure their growth. Meeting the water quality maintenance needs will have large benefits to withdrawal and instream uses which are dependent upon good quality water as well as being beneficial to the visual and cultural needs of the Area.

High benefits can be expected from satisfying the irrigation, erosion and drainage control needs since agriculture is a vital part of the economy of the Area. Fairly high benefits will accrue to Area 20 and the urban portions of adjacent areas from satisfying the recreation, fish and wildlife and visual and cultural needs. The benefits from navigation and flood damage reduction will be fairly small but are still important to the Area's economic development.

Costs. Water quality maintenance costs for both advanced and secondary treatment facilities are by far the largest in Area 20 and will increase considerably throughout the planning period. In the lower reaches the quality of the water may be such that water quality standards can be met solely through storage for low flow augmentation.

Visual and cultural costs will be high, particularly in the first planning phase to provide fee simple purchase of the unique landscape between the Rappahanock and Potomac Rivers to protect it from expansion of the Washington, D.C., metropolitan area. Other significant costs include publicly supplied water in the first planning period from the use of storage. Upstream flood damage reduction costs will be higher in the first and third planning periods. Commercial navigation costs will occur only during the first period while recreational boating costs will increase throughout the planning period. The lower costs for water recreation and irrigation water will remain fairly constant. Erosion control costs will be fairly large.

Alternative Programs. If Environmental Quality were chosen to receive primary emphasis in Area 20, the needs of agricultural irrigation would be significantly higher throughout the planning period. Publicly supplied and industrial self-supplied water needs would be slightly lower in the last two planning periods. Visual and cultural needs would be more costly and fulfilled over all three planning periods rather than in the first two. Erosion control and water recreation needs would also be constantly higher and cost more. Power plant cooling needs would be lower and would be met by lower fresh water withdrawal and consumption and higher brackish water consumption.

Saline withdrawals would also decrease. The use of non-condensing facilities would increase costs. Cropland drainage control would be slightly higher, but cost more only in the first planning period. The needs of commercial navigation would be lower and channel improvements would not be made. Upstream flood damage reduction needs would be met by increased use of reservoirs, channels and river projects.

If Regional Development were to be emphasized in the Area, agricultural irrigation needs would increase. Publicly supplied and industrial self-supplied water needs would be slightly larger. Forest and cropland drainage and erosion control needs would be higher throughout the planning period. Upstream flood damage reduction needs would remain the same, but in the two early planning periods less flood plain and watershed management and more reservoirs, river projects and channels would be used. Power plant cooling needs would be slightly lower in the second and third periods as much of the power would be generated in adjacent Areas. Visual and cultural needs would be larger and fulfilled throughout all three planning periods rather than in just the first two. Commercial navigation needs would be slightly higher. Water recreation needs and costs would also be slightly higher.

If National Income were emphasized there would be very few changes from the recommended program. Upstream flood damage reduction needs would use less flood plain and watershed management for this need would be more spread out over all time periods.

AREA 20

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	18	26	42	68
Industrial Self-Supplied Water (mgd)	50	83	117	132
Rural Water Supply (mgd)	11	16	23	35
Irrigation Water: agriculture (1000 afy)	1.1	2.7	2.7	2.7
non-agriculture (1000 afy)	0.4	2.3	4.7	8.3
Power Plant Cooling: withdrawal, saline (cfs)	400	400	3800	7900
brackish (cfs)	0	0	0	0
fresh (cfs)	0	130	150	120
consumption, brackish (cfs)	0	0	0	0
fresh (cfs)	0	82	90	58
Hydroelectric Power Generation (mw)	0	0	100	100
Navigation: commercial (m. tons annually)	5	8	12	18
recreational boating (1000 boats)	8	10	15	21
Water Recreation: visitor days (m.)	x	11	19	33
stream or river (miles)	x	29	46	68
water surface (1000 acres)	x	5.3	8.4	12.6
beach (acres)	x	48	75	109
pool (m. sq. ft.)	x	0.9	1.5	2.1
land facilities (1000 acres)	x	1.9	2.9	4.3
Fish & Wildlife: sport fishing man-days (m.)	1.0	1.2	1.6	2.0
surface area, lake (acres)	x	0	1400	3800
stream (acres)	x	710	720	730
access, fresh (acres)	x	33	48	77
salt (acres)	x	40	110	200
anadromous (acres)	x	4	12	22
piers (1000 feet)	x	1.0	3.0	5.4
hunting man-days (m.)	1.0	1.1	1.4	1.8
access (1000 sq. mi.)	x	0.1	1.2	1.6
nature study man-days (m.)	0.47	0.56	0.73	0.94
access (1000 acres)	x	0.7	2.7	6.1
Water Quality Maint.: non-industrial (m. PEs)	0.07	0.38	0.52	0.74
industrial (m. PEs)	0.2	0.6	1.5	4.6
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	1.0	1.4	2.5	4.6
mainstream (m.$)	0.3	0.5	1.1	2.3
tidal & hurricane (m.$)	0.5	0.8	1.7	3.5
Drainage Control: cropland (1000 acres)	50	65	90	90
forest land (1000 acres)	x	0	16	64
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	1100	1200	1300	1300
urban (1000 acres)	160	160	200	260
stream bank (mi.)	x	7	25	43
coastal shoreline (mi.)	x	1	3	5
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq.mi.)	x	1000	1000	1000
unique shoreline (mi.)	x	64	64	64
high quality (sq.mi.)				
diversity (sq.mi.)	x	500	900	900
agriculture (sq.mi.)				
landscape development, quality (sq.mi.)				
diversity (sq.mi.)				
metro. amenities (mi.)				
" " (sq.mi.)				

ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
1980	2000	2020	1980	2000	2020	1980	2000	2020
26	38	57	26	42	68	27	43	69
83	109	115	83	117	132	86	124	146
			16	23	35			
51.9	160.6	191.1	2.4	2.4	2.4	51.9	160.6	160.6
3.0	5.0	7.0	2.0	4.0	7.0	3.0	5.0	7.0
400	3200	6500	400	3800	7900	400	3200	6500
0	20	45	0	0	0	0	0	0
130	130	40	130	150	120	130	140	80
0	8	18	0	0	0	0	0	0
82	82	36	82	90	58	82	89	53
			0	100	100			
6	8	10	8	12	18	8	13	22
			10	15	21			
13	22	37	11	19	33	13	22	38
88	138	207	29	46	68	44	68	102
17.1	27.1	41.1	5.3	8.4	12.6	9.0	15.3	22.7
172	270	390	48	75	109	135	212	305
3.0	4.7	6.8	0.9	1.5	2.1	2.3	3.7	5.2
9.9	15.3	22.6	1.9	2.9	4.3	3.6	5.3	7.8
			1.2	1.6	2.0			
			0	1400	3800			
			710	720	730			
			33	48	77			
			40	110	200			
			4	12	22			
			1.0	3.0	5.4			
			1.1	1.4	1.8			
			0.1	1.2	1.6			
			0.56	0.73	0.94			
			0.7	2.7	6.1			
			0.38	0.52	0.74			
			0.6	1.5	4.6			
			1.4	2.5	4.6			
			0.5	1.1	2.3			
			0.8	1.7	3.5			
75	100	100	65	90	90	75	100	100
0	16	64	0	16	64	16	64	209
1300	1500	1500	1200	1300	1300	1300	1520	1500
240	370	440	160	200	260	240	370	440
36	108	180	7	25	43	18	54	90
53	107	113	1	3	5	2	5	8
x	x	x	x	x	x	x	x	x
1000	1000	1000	1000	1000	1000	Same	as	EQ
64	64	64	64	64	64	Same	as	EQ
300	600	900	300	600	900	Same	as	EQ

AREA 20

DEVICES—incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ϕ				
reservoirs, upstream (1000 af)	FW,Rec	1*	4*	x
mainstream (1000 af)	FW,Rec,VC	35*	26*	7*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	Ind,Pow,Irrig	30	31	13
brackish (mgd)	Ind	56	115	204
estuarine (mgd)				
ocean (mgd)	Pow	x	x	x
wells (mgd)		7*	13*	12*
Conveyance Facilities				
interbasin diversions, into (mgd)				
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	4.9	13.7	17.7
waste treatment plants				
secondary (85%) (m. PE removed)				
secondary (90%) (m. PE removed)	WQ,VC	0.9	1.8	4.8
advanced (95%) (m. PE removed)	WQ,VC	0.05	0.10	0.27
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ,VC	x	x	x
Pumped Storage				
Desalting Facilities				
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	24	90	17
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)				
river (projects)	FDR	1	0	8
flood control channels (mi.)	FDR	0	0	90
Watershed Management (1000 acres)	FDR,Drn,VC	10	0	450
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x		
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig
≠ Also includes the following purposes: Rec,FW
⧣ Also includes the following purposes: Ind and Pow

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig ≁	41	87	24	Irrig ≁	1	x	x	Irrig ≁	41	87	x
PS,WQ ≁	71	x	3	PS,WQ ≁	71	x	4	PS,WQ ≁	80	x	4
Irrig ≠	30	23	6	Irrig ≠	30	31	13	Irrig ≠	33	36	20
Ind	56	105	168	Ind	56	115	204	Ind	57	126	236
Pow		x	x								
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	20	32	22	Rur**	10	14	20	Rur**	20	33	19
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
PS	4.9	10.3	13.0	PS	4.9	13.7	17.7	PS	5.5	13.7	17.7
				WQ,VC	0.9	1.8	4.8				
				WQ,VC	0.05	0.10	0.27				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
FDR,VC	24	90	17	FDR,VC	1	1	x	FDR,VC	1	x	1
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
FDR	9	7	6	FDR	1	0	8	FDR	1	6	2
FDR	90	170	150	FDR	0	0	90	FDR	0	70	20
FDR,Drn,VC	330	660	660	FDR,Drn,VC	10	x	450	FDR,Drn,VC	10	270	180
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x			Nav	x		
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 20

DEVICES-incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	500	0	0
fee simple purchase (buying) (mi.)	VC, FW	32	0	0
purchase lease (sq.mi.)				
easements (sq.mi.)	VC, FW	250	200	0
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)				
zoning (sq.mi.)				
zoning (mi.)				
zoning and/or tax inc. subs.(sq.mi.)	VC, FW	750	200	0
zoning and/or tax inc. subs. (mi.)	VC, FW	32	0	0
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW, VC	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways				
Stocking, fish	FW	x	x	x
wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research				
III. Education				
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities				
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project				
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	37	0	130
Mainstream Flood Control Storage(1000af)	FDR	0	260	0
Protect Shellfish	Hlth	x	x	x
Hydroelectric Generation Storage	HPG		x	

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	1150	150	150	VC, FW	500	0	0	Same	as	EQ	
VC, FW	64	0	0	VC, FW	32	0	0	"	"	"	
VC, FW	150	150	150	VC, FW	150	150	150	"	"	"	
VC,FW	0	0	0	VC, FW	650	150	150	"	"	"	
VC,FW	0	0	0	VC, FW	32	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
←				FW	x	x	x	→			
VC	x	x	x	VC	x	x	x	Same	as	EQ	
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				FW	x	x	x	→			
←				Hlth	x	x	x	→			
Pow		x	x								
FW			x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	167	102	87	FDR	37	0	130	FDR	37	71	59
FDR	0	260	0	FDR	0	260	0	FDR	0	260	0
HPG		x		HPG		x		HPG		x	

AREA 20

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE 1980	2000	2020	
Water Development Costs:				
storage, upstream	0.2*	5.0*	0*	
mainstream	22.7*	6.8*	1.6*	
wells	2.5*	4.6*	4.5*	
desalting				
Water Withdrawal and Conveyance Costs:				
inter-basin transfers				
public water supply	2.2	5.1	6.2	
industrial self-supplied water	0.46	0.80	1.17	
rural water supply	x	x	x	
irrigation, agriculture	0.10	0	0	
nonagriculture	1.4	1.5	2.1	
Power Plant Cooling Water	0	0	0	
Hydroelectric Power Generation		x		
Navigation: commercial	24	0	0	
recreation	0.8	2.4	3.6	
Water Recreation	2.9	2.2	3.7	
Fish and Wildlife: fishing	0.63	0.53	0.81	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	110	220	570	
advanced	10	21	55	
other ⸸				
Flood Damage Reduction: upstream	8	0	14	
mainstream	0	20	0	
Drainage Control	1.3	3.0	2.2	
Erosion Control	6	11	12	
Health	x	x	x	
Visual and Cultural	114	24	0	
Summation of Available Estimated Costs	310	330	680	

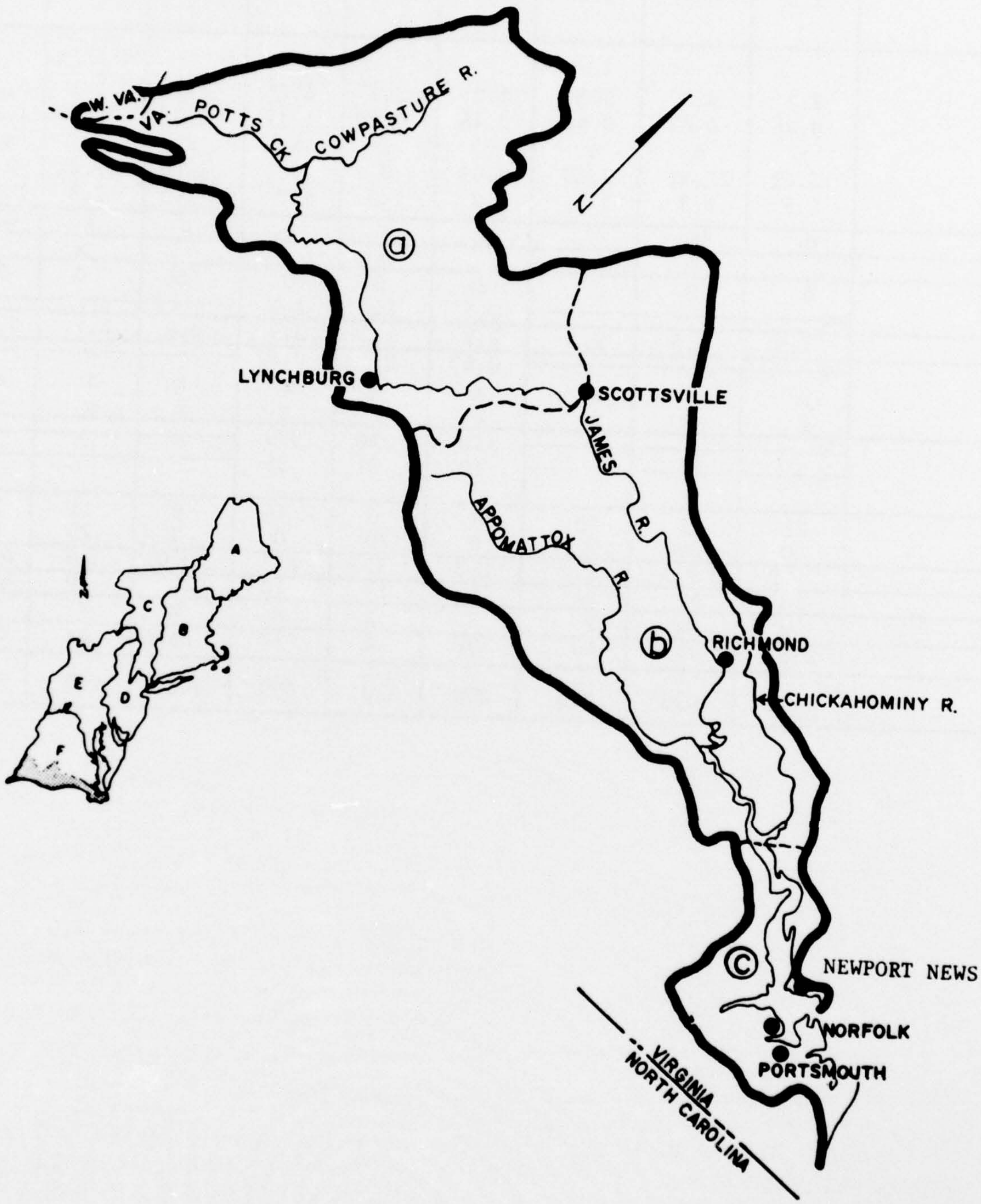
*From the supply model and includes OMR costs.

⸸ Combined sewer overflows control and acid mine drainage control.

AREA 20

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	3.6 25.4 1.4	7.9 0 2.5	2.2 2.1 1.1	0.024 25.4 0.4	0 0 0.5	0 2.4 0.7	3.6 28.6 1.4	7.9 0 2.5	0 2.4 0.6
	2.2 0.46 x 12.62 1.5	4.3 0.69 x 27.82 1.3	5.3 0.94 x 7.80 1.5	2.2 0.46 x 0.09 1.2	5.1 0.80 x 0 1.3	6.2 1.17 x 0 1.8	2.2 0.48 x 12.62 1.5	5.1 0.88 x 27.82 1.3	6.2 1.39 x 0 1.5
	0	36	77	0	0	0	0	9	23
		x			x			x	
	0	0	0	24	0	0	24	0	0
	←			0.8	2.4	3.6			→
	7.5	4.5	9.3	2.9	2.2	3.7	3.9	2.7	5.1
	←			0.63	0.53	0.81			→
	x x	x x	x x	x x	x x	x x	x x	x x	x x
	←			110	220	570			→
	←			10	21	55			→
	21 0	13 20	13 0	8 0	0 20	14 0	8 0	11 20	2 0
	2.2	3.0	2.2	1.3	3.0	2.2	3.0	4.4	6.5
	58	62	21	6	11	12	26	30	18
	x	x	x	x	x	x	x	x	x
	208	40	40	102	18	18	Same	as	EQ
	470	470	810	300	310	690	440	410	740

AREA 21 JAMES RIVER BASIN



AREA 21

James River Basin. Area 21 consists of the entire James River Basin and the Atlantic Coastal drainage from Old Point Comfort to Virginia Beach, Virginia. The Area, consisting of 10,600 square miles, is located almost entirely within the State of Virginia with only a small western portion in West Virginia. There are three sub-areas in Area 21: sub-area a is the James River drainage above Scottsville, Virginia; sub-area b begins above the James River's confluence with the Chickahominy River; and sub-area C is the remainder of the James River basin and all of the coastal drainage.

There are four fairly large urban centers in the Area with two of them, Norfolk and Newport News, located in the vicinity of Hampton Roads which is one of the largest and finest harbors in the NAR. The two other centers are Lynchburg and Richmond.

Area topography varies from rugged Appalachian Mountains to rolling hills and a flat coastal plain. The landscape pattern is nearly 50 percent farm-forest with another third forest-wildland and some small amount of city and farm. The majority of the landscape is of medial quality - two-thirds - and the remainder is of low quality. Some high quality but unpreserved coastline exists in the Area. There is a high concentration of historic sites and a wide range of landscapes that provide a fair amount of diverse activities.

The 1960 population of Area 21 was 1.7 million with a density of 150 people per square mile. The density was 40 people per square mile in sub-area a, 133 in b and 686 in c. The Area's population is projected to total 3.2 million by 2020, an increase of almost 100%.

Per capita income was 11.4% below the national average in 1959 but is expected to increase to only 5% below by 2020.

Employment in the Area was 0.6 million in 1960 and is expected to increase by 117% to 1.3 million by 2020. Industries with the largest 1960 employment include wholesale and retail trade; services; public administration; and transportation, communication and public utilities. Employment is expected to decrease in agriculture, forestry and fisheries; mining; food and kindred products; and petroleum and coal products.

Water is generally plentiful in the upper reaches of the Area, but diversions may be necessary to meet the water supply needs of the heavily populated and industrial regions near the coast. Municipal and industrial pollution seriously degrade portions of the Area, particularly the James River below Richmond and Lynchburg.

Area 21's average annual runoff is approximately 7,450 m.g.d. The existing minimun monthly flow (shortage index 0.01) is 880 m.g.d., and the corresponding seven-day minimum is about 55% of this or 480 m.g.d. (See Appendix C). Allowance for yield from Gathright Lake raises the latter value to about 597 m.g.d. The addition of 77 m.g.d. for con-

sumptive losses, results in a firm resource available for use of about 674 m.g.d., or 9% of the average runoff.

The practical limit of development within the Area, based on potential yield of new surface storage and additional ground water, would provide a maximum available resource of 2,938 m.g.d., or 39% of the average runoff. Potential sources which would develop the increase of 2,264 m.g.d., include major storage, accounting for 34% of the increase; upstream storage, 41%, and ground water development, 25%.

Possible Alternative Planning Objectives. The complete range of NAR planning objectives can be considered for Area 21. The low level of per capita income would be affected by a Regional Development emphasis, while the medial quality landscape and poor water quality would be aided by emphasizing Environmental Quality. National Income would not be emphasized alone, but would be emphasized along with the other objectives because of the variety and degree of the Area's problems. The vast differences in population densities and industrial development could require different objective mixes for the sub-areas.

Recommended Mixed Objective. It is recommended that the overall objective for Area 21 be Regional Development augmented by some degree of National Income and Environmental Quality. Regional Development should be employed to raise per capita income levels in several metropolitan sectors and in the Appalachia portion of the Area. National Income should be used for those metropolitan sectors of the Area which have higher per capita income levels. Environmental Quality should be used for conserving and developing the coastal and interior landscapes and other natural resources, and for improving the presently poor water quality.

Needs. This will be an Area of rapid industrial growth for the next fifty years and its water withdrawal needs will be very large and important for industrial self-supplied and power plant cooling needs. Power plant cooling needs for saline water withdrawal will grow especially rapidly during the second planning period to keep pace with industrial expansion. Instream needs for water quality maintenance will be fairly high and grow rapidly especially in the later time periods as the Area's industry and energy production increase. Water quality maintenance will be key in helping to attain the fish and wildlife needs associated with Chesapeake Bay and with the oyster industry in the James River estuary.

Commercial navigation needs are large in this Area and these will be very important to the Area's mixed objective and its industrial growth. Rural water supply needs will grow fast and be large in this Area compared to the Regional average and their fulfillment will help achieve the Regional Development objective throughout the Area, not just in the larger population centers.

There will be significant hydroelectric power generation needs in the Area by 2020 as a result of the growth in industry and population and because there are many sites available in the Area for pumped-storage facilities. Publicly supplied water needs are moderate and keep pace with the Area's population growth.

Visual and cultural needs will be fairly small except for maintaining unique shoreline landscapes which will be large. These needs will be met in the first time frame to help insure preservation and improvement of the Area's landscape resources before the full force of the population and industrial growth are felt.

Many of the fish and wildlife needs will be large and grow quickly throughout the planning period in Area 21. This is a result of the expected increases in population that are close to fairly extensive fish and wildlife resources of the Area.

Flood damage reduction needs due to tidal and hurricane damages and for mainstream damages will be fairly large. This will be because of the concentration of population and industry along the mainstream and at the mouth of the James River which is vulnerable to coastal storms.

Urban, streambank and coastal shoreline erosion needs will grow rapidly and, along with agricultural erosion control, will be large in this Area.

Some of the other Area needs have steady growth rates but they are not as important as the above needs in fulfilling the mixed objective. These needs include water recreation, recreational boating and forest drainage control. Non-agricultural irrigation grows fairly rapidly but is also not as important to the Area's mixed objective.

Needs with slow growth rates include cropland drainage control and agriculture erosion control needs.

Devices. Many important water needs of the Area are dependent upon reservoir storage facilities in the James River Basin because of the deficiencies of other sources. The needs requiring these multiple purpose reservoirs include publicly supplied water, irrigation water, water quality maintenance and flood damage reduction. All of the withdrawal and conveyance facilities will be required in this Area for these needs.

Wells can be used to partially fulfill some needs - publicly supplied water, industrial self-supplied water, rural water supply and irrigation water - because groundwater is available in limited portions of the Area. The large and important power plant cooling needs will be fulfilled adequately only by shifting from fresh to brackish and then to saline water sources to prevent thermal pollution of

available fresh water supplies. These fresh water supplies will be needed to support increasing quantities of other withdrawal and instream needs. Cooling towers will be used while fulfilling power plant cooling needs in the Area when it is feasible.

Water quality control facilities will be used more as the planning period progresses to meet the increasing water quality maintenance needs and the increasing instream needs such as water recreation, fish and wildlife and water withdrawal needs.

Rural water supply needs will grow at a decreasing rate because of an increasing expansion of central water supply systems that will increasingly fulfill rural needs. Changes in commercial navigation facilities will be limited by the 55-foot maximum draft allowed by the Chesapeake Bay bridge-tunnel and the Norfolk Harbor tunnel.

Flood plain management will be used to help meet flood damage reduction needs although reservoirs will be the primary device. Watershed management will also be used for upstream needs.

Education programs should be developed to inform the Area's population of their water resources management problems and possible solutions. This program will be especially helpful for resolving siting problems of pumped-storage facilities.

Early purchasing of land will be necessary to meet visual and cultural needs before the land becomes more expensive, scarce and difficult to preserve. The needs that will be met include maintenance of unique natural and unique shoreline landscapes and development of metropolitan amenities.

Benefits. Reservoirs will provide the largest and most important benefits to the recommended program. There will be many benefits from the reduced costs of using multiple-purpose facilities for meeting the needs of publicly supplied water, industrial self-supplied, water recreation, fish and wildlife, irrigation water and flood damage reduction. Meeting water quality maintenance needs will also provide large benefits to withdrawal and instream needs such as water supply and water recreation. This will be especially true during the later time frames. In addition, visual and cultural and health needs will benefit from water quality maintenance.

Wells will provide relatively large benefits especially in those parts of the Area which have large withdrawal needs combined with locally available groundwater.

Improvements in mainstream channels for commercial navigation will produce substantial benefits for the Area's Regional Development and will also provide some benefits for recreational boating needs. Cooling towers for power plant cooling needs will provide substantial benefits to other

water withdrawal needs especially industrial self-supplied water and fish and wildlife instream needs.

Provision of access along with early landscape preservation will greatly increase the benefits to water recreation, fish and wildlife and visual and cultural needs as the population grows and as natural resources become increasingly scarce.

Costs. Water quality maintenance costs will be very high, especially in the later planning periods as the industrial and population pollution loading grows and as a higher degree of treatment is required. Publicly supplied water costs will be high and industrial self-supplied water and power plant cooling costs will be fairly high in later time periods. Some of the costs for power plant cooling will be due to the increased use of cooling devices and some reliance on non-condensing facilities.

Agriculture irrigation costs will be fairly low and commercial navigation costs will be very high in the last two planning periods. The benefits from meeting both needs, however, will help meet the Regional Development emphasis of the Area's mixed objective.

Costs for mainstream flood damage reduction will be fairly large during the second planning period with very high costs for upstream flood damage reduction during all time periods. Erosion control costs will be fairly large and will be important in helping to meet the Area's mixed objective.

Visual and cultural needs should be fulfilled in the first time frame of the program to avoid having to meet rapidly increasing costs. Water recreation costs will be fairly small but will increase throughout the planning period.

Other needs are of small importance and have low costs. These include rural water supply, agricultural irrigation, fish and wildlife and drainage control.

Alternative Programs. Emphasizing Environmental Quality in Area 21 would result in publicly supplied and industrial self-supplied water needs and costs being lower. Agricultural irrigation needs would be much larger to enhance the Area's landscapes. Power plant cooling needs would be reduced. Saline and freshwater withdrawals would decrease in the last two planning periods. Brackish withdrawals and fresh consumption would increase slightly in the second planning period and then decrease in the last period. Brackish consumption would increase in the last two periods. This would reduce some of the thermal pollution in the Area providing additional benefits to water recreation, fish and wildlife and visual and cultural needs.

Commercial navigation needs would be only slightly reduced along with costs. There would be no use of obstruction removal. Water recreation needs for visitor days would be reduced but the other recreation needs would be slightly raised to provide higher quality experiences at higher costs. No reservoirs would be used for mainstream flood damage reduction needs to reduce damages to the environment.

If National Income were emphasized, irrigation needs and costs would be reduced to a slight extent to allow agriculture to be more efficient. Publicly supplied and industrial self-supplied water needs would be smaller. Power plant cooling needs would increase as non-condenser devices would not be used. Fresh water withdrawals would be increased during the second planning period and decreased the last period as fresh water consumption would decrease to reduce costs. Water recreation needs would be lowered as less attention would be given to high quality recreational experiences. Fewer upstream flood damage reduction needs would be met in the Area as more efficient use of storage sites would be made and less attention would be given to flood plain management projects. Reductions would be made in cropland drainage control and all erosion control needs and costs which were oriented towards increasing environmental quality. Visual and cultural needs would be fulfilled by a change in the type of land management devices, with equal emphasis given to zoning and purchase. This change would reduce the costs.

If Regional Development were emphasized alone, agricultural irrigation needs and costs would be much larger in all time periods to increase the Area's income. Power plant cooling needs would be larger since non-condenser devices would not be in use. During the last two planning periods there would be decreases in saline and freshwater withdrawals and increases in brackish withdrawals and consumption and in fresh water consumption. Upstream flood damage reduction needs would be met differently to reduce costs while forest land drainage control needs would be higher to increase production. Streambank and shoreline erosion control needs would be smaller. Commercial navigation needs would be increased.

AREA 21

NEEDS-cumulative	Pres.	MIXED OBJECTIVE 1980	2000	2020
Publicly Supplied Water (mgd)	190	250	360	520
Industrial Self-Supplied Water (mgd)	400	770	1320	1790
Rural Water Supply (mgd)	22	34	51	59
Irrigation Water: agriculture (1000 afy)	2.4	7.7	8.3	7.9
non-agriculture (1000 afy)	2	10	18	29
Power Plant Cooling: withdrawal, saline (cfs)	800	700	3800	14000
brackish (cfs)	0	3400	5300	3000
fresh (cfs)	1800	1700	3100	4800
consumption, brackish (cfs)	0	35	49	30
fresh (cfs)	20	20	100	240
Hydroelectric Power Generation (mw)	30	1500	2000	3000
Navigation: commercial (m. tons annually)	80	80	120	180
recreational boating (1000 boats)	44	51	78	125
Water Recreation: visitor days (m.)	x	34	54	82
stream or river (miles)	x	110	160	220
water surface (1000 acres)	x	23	33	46
beach (acres)	x	350	510	660
pool (m. sq. ft.)	x	6.0	8.8	11.3
land facilities (1000 acres)	x	8.8	12.7	16.9
Fish & Wildlife: sport fishing man-days (m.)	4.1	5.0	6.4	8.0
surface area, lake (acres)	x	3.9	8.5	14.0
stream (acres)	x	5400	5400	5400
access, fresh (acres)	x	68	133	201
salt (acres)	x	390	920	1560
anadromous (acres)	x	62	84	110
piers (1000 feet)	x	11	26	44
hunting man-days (m.)	2.3	2.6	3.3	4.1
access (1000 sq. mi.)	x	0.1	1.1	1.4
nature study man-days (m.)	2.2	2.7	3.4	4.3
access (1000 acres)	x	0.2	0.8	1.5
Water Quality Maint.: non-industrial (m. PEs)	1.1	2.1	2.6	3.2
industrial (m. PEs)	2.6	6.8	17.4	40.0
Flood Damage Reduction:				
avg. ann. damage, upstream (m.$)	2.5	4.0	7.4	14.4
mainstream (m.$)	3.2	5.4	11.0	23.0
tidal & hurricane (m.$)	1.8	3.1	6.2	13.0
Drainage Control: cropland (1000 acres)	45	67	89	89
forest land (1000 acres)	x	0	15	60
wet land (1000 acres)				
Erosion Control: agriculture (1000 acres)	1600	2000	2200	2300
urban (1000 acres)	430	450	630	950
stream bank (mi.)	x	60	180	300
coastal shoreline (mi.)	x	27	55	62
Health: vector control and pollution control	x	x	x	x
Visual & Cultural:				
landscape maintenance, unique natural (sq. mi.)	x	80	80	80
unique shoreline (mi.)	x	80	80	80
high quality (sq. mi.)				
diversity (sq. mi.)				
agriculture (sq. mi.)				
landscape development, quality (sq. mi.)				
diversity (sq. mi.)				
metro. amenities (mi.)				
" " (sq. mi.)	x	11	11	11

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	230	320	430	250	360	520	250	360	520
	750	1170	1440	750	1240	1610	770	1320	1790
				34	51	59			
	59.2	172.4	207.6	6.4	6.8	6.5	59.2	172.4	172.1
	12	20	29	10	18	29	10	19	29
	700	600	7800	700	3800	14000	700	1800	12800
	3400	5400	150	3400	5300	3000	3400	6300	1800
	1700	1300	600	1700	4700	11300	1700	2900	3200
	35	89	70	35	49	30	35	70	48
	20	100	230	20	90	230	20	100	280
				1500	2000	3000			
	70	100	150	80	120	180	90	120	200
				51	78	125			
	33	52	81	29	46	67	34	54	82
	220	330	460	70	110	150	110	160	220
	43	64	88	12	18	25	23	33	46
	440	650	840	120	180	240	350	510	660
	7.7	11.3	14.6	2.4	3.5	4.6	6.0	8.8	11.3
	25.2	36.3	48.4	4.6	6.6	8.8	8.8	12.7	16.9
				5.0	6.4	8.0			
				3.9	8.5	14.0			
				5400	5400	5400			
				68	133	201			
				390	920	1560			
				62	84	110			
				11	26	44			
				2.6	3.3	4.1			
				0.1	1.1	1.4			
				2.7	3.4	4.3			
				0.2	0.8	1.5			
				2.1	2.6	3.2			
				6.8	17.4	40.0			
				4.0	7.4	14.4			
				5.4	11.0	23.0			
				3.1	6.2	13.0			
	67	89	89	59	80	80	67	89	89
	0	15	60	0	15	60	15	60	195
	2000	2200	2300	1800	1900	1900	2000	2200	2300
	440	630	950	440	550	720	450	630	950
	60	180	300	10	40	70	30	90	150
	27	55	62	1	3	5	2	6	10
	x	x	x	x	x	x	x	x	x
	80	80	80	80	80	80	Same	as	EQ
	80	80	80	80	80	80	Same	as	EQ
	11	11	11	11	11	11	Same	as	EQ

AREA 21

DEVICES-incremental	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
I. Resource Management				
A. Water				
Storage Facilities ¢				
reservoirs, upstream (1000 af)	FW,Rec,VC	10.7*	1.4*	x*
mainstream (1000 af)	FW,Rec,VC,WQ	8*	191*	255*
Withdrawal Facilities				
intakes & pumping, fresh (mgd)	PS,Ind,Pow,Irrig	390	580	530
brackish (mgd)	Ind	22	38	36
estuarine (mgd)	Pow	x	x	x
ocean (mgd)	Pow	x	x	x
wells (mgd)		18*	52*	262*
Conveyance Facilities				
interbasin diversions, into (mgd)		25*	0*	0*
out of (mgd)				
Quality Control Facilities				
temperature, cooling towers & ponds	Pow,WQ	.x	x	x
chemical/biological				
potable water treat plants (mgd)	PS	43	116	191
waste treatment plants				
secondary (85%) (m. PE removed)	WQ,VC	7.5	0	0
secondary (90%) (m. PE removed)	WQ,VC	0	18	39
advanced (95%) (m. PE removed)	WQ,VC	0	1.0	2.2
effluent irrigation				
nutrient control	WQ,VC	x	x	x
stormwater discharge control	WQ,VC	x	x	x
acid mine drainage control				
septic tank control				
separate combined sewers	WQ,VC	x	x	x
Pumped Storage	HPG	x	x	x
Desalting Facilities		12*	85*	119*
Monitoring Facilities				
B. Water/Land				
Flood Plain Management				
upstream (1000 acres)	FDR,VC	51	127	10
mainstream (1000 acres)	FDR,VC	x	x	x
Local Flood Protection				
ocean (projects)	FDR	0	1	0
river (projects)	FDR	27	22	20
flood control channels (mi.)	FDR	72	157	156
Watershed Management (1000 acres)	FDR,Drn,VC	690	1380	1380
Erosion Protection, land treatment	Ern	x	x	x
coastal shoreline	Ern,Rec	x	x	x
river shoreline	Ern	x	x	x
Drainage Practices	Drn	x	x	x
Waterway Management				
navigation channel improvement	Nav	x	x	x
debris removal				
recreation boating facilities	Rec,Nav	x	x	x

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
ϕ Flood control storage not included.

** Also includes the following purposes: PS,Ind,Irrig
ƒ Also includes the following purposes: VC,Rec,FW

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
Irrig $\not+$	45.4	90.6	28.2	Irrig $\not+$	3.2	0.3	x	Irrig $\not+$	45.4	90.6	x
PS,WQ $\not+$	x	71	x	PS,WQ $\not+$	x	75	x	PS,WQ $\not+$	x	76	x
Pow**	360	450	300	Pow**	370	520	440	Pow**	390	580	530
Ind	22	23	22	Ind	22	29	35	Ind	22	38	36
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Pow	x	x	x	Pow	x	x	x	Pow	x	x	x
Rur**	43	63	37	Rur**	33	46	39	Rur**	44	68	41
PS	0	18	18	PS	0	29	31	PS	0	30	31
Pow,WQ	x	x	x	Pow,WQ	x	x	x	Pow,WQ	x	x	x
PS	29	97	129	PS	42	114	189	PS	43	116	191
				WQ,VC	7.5	0	0				
				WQ	0	18	39				
				WQ	0	1.0	2.2				
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
WQ,VC	x	x	x	WQ,VC	x	x	x	WQ,VC	x	x	x
				HPG	x	x	x				
FDR,VC	51	127	10	FDR,VC	4	4	3	FDR,VC	4	3	3
FDR,VC	x	x	x	FDR,VC	x	x	x	FDR,VC	x	x	x
				FDR	0	1	0	FDR	0	1	0
FDR	27	20	20	FDR	3	10	16	FDR	6	19	10
FDR	72	157	156	FDR	23	17	32	FDR	23	49	57
FDR,Drn,VC	690	1380	1380	FDR,Drn,VC	70	200	500	FDR,Drn,VC	200	470	100
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Ern,Rec	x	x	x	Ern,Rec	x	x	x	Ern,Rec	x	x	x
Ern	x	x	x	Ern	x	x	x	Ern	x	x	x
Drn	x	x	x	Drn	x	x	x	Drn	x	x	x
				Nav	x	x	x	Nav	x	x	x
Rec,Nav	x	x	x	Rec,Nav	x	x	x	Rec,Nav	x	x	x

AREA 21

DEVICES—incremental (cont.)	MIXED OBJECTIVE			
	Purposes	1980	2000	2020
C. Land				
Controls				
fee simple purchase (buying)(sq.mi.)	VC, FW	91	0	0
fee simple purchase (buying) (mi.)	VC, FW	80	0	0
purchase lease (sq.mi.)				
easements (sq.mi.)				
deed restrictions (sq.mi.)				
tax incentive subsidy (sq.mi.)	VC, FW	x	x	x
zoning (sq.mi.)	VC,FW	0	0	0
zoning (mi.)	VC,FW	0	0	0
zoning and/or tax inc. subs.(sq.mi.)				
zoning and/or tax inc. subs. (mi.)				
Facilities				
recreation development	Rec	x	x	x
overland transportation to facility	Rec	x	x	x
parking and trails	FW	x	x	x
site sanitation and utilities	VC	x	x	x
D. Biological				
Habitat Management, fish	FW	x	x	x
wildlife	FW	x	x	x
Fishways	FW	x	x	x
Stocking, fish wildlife	FW	x	x	x
Water Quality Standards Enforcement	FW	x	x	x
Insect Control	Hlth	x	x	x
II. Research	WQ	x	x	x
III. Education	Pow	x	x	
IV. Policy Changes				
Water Demand and Allocation Changes				
pricing and rationing				
non-condenser power facilities	Pow		x	x
re-circulation (internal)				
Project Operational Changes				
remove restrictions				
remove project	FW	x	x	x
add new project needs	Rec, FW	x	x	x
change project design load	Rec	x	x	x
V. Others				
Upstream Flood Control Storage (1000af)	FDR	240	238	238
Mainstream Flood Control Storage(1000af)	FDR	0	239	0

ENVIRONMENTAL QUALITY				NATIONAL INCOME				REGIONAL DEVELOPMENT			
Purposes	1980	2000	2020	Purposes	1980	2000	2020	Purposes	1980	2000	2020
VC, FW	91	0	0	VC, FW	51	0	0	Same	as	EQ	
VC, FW	80	0	0	VC, FW	40	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	40	0	0	"	"	"	
VC,FW	0	0	0	VC, FW	40	0	0	"	"	"	
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
				FW	x	x	x				
VC	x	x	x	VC	x	x	x	Same	as	EQ	
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				FW	x	x	x				
				Hlth	x	x	x				
WQ	x	x	x	WQ	x	x	x	WQ	x	x	x
Pow		x	x								
				FW	x	x	x				
FW, Rec	x	x	x	FW, Rec	x	x	x	FW, Rec	x	x	x
Rec	x	x	x	Rec	x	x	x	Rec	x	x	x
FDR	240	238	238	FDR	19	52	169	FDR	58	144	50
				FDR	0	239	0	FDR	0	239	0

AREA 21

FIRST COSTS - incremental ($ million 1970)	MIXED OBJECTIVE 1980	2000	2020	
Water Development Costs:				
storage, upstream	1.4*	0*	0*	
mainstream	4*	30*	43*	
wells	4.1*	6.4*	13.0*	
desalting	40*	250*	290*	
Water Withdrawal and Conveyance Costs:				
inter-basin transfers	1.9*	0*	0*	
public water supply	41	79	124	
industrial self-supplied water	2.05	3.08	2.63	
rural water supply	x	x	x	
irrigation, agriculture	0.61	0.15	0	
nonagriculture	6.4	5.3	7.5	
Power Plant Cooling Water	0	16	28	
Hydroelectric Power Generation	x	x	x	
Navigation: commercial	150	360	175	
recreation	2.9	6.0	7.3	
Water Recreation	10	37	101	
Fish and Wildlife: fishing	3.2	3.1	3.6	
hunting	x	x	x	
nature study	x	x	x	
Water Quality Maint.: waste treatment, secondary	850	1920	4140	
advanced	0	210	440	
other ≠				
Flood Damage Reduction: upstream	38	31	26	
mainstream	0	51	0	
Drainage Control	2.0	2.7	2.0	
Erosion Control	80	97	62	
Health	x	x	x	
Visual and Cultural	30	0	0	
Summation of Available Estimated Costs	1300	3100	5500	

*From the supply model and includes OMR costs.

≠ Combined sewer overflows control and acid mine drainage control.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	4.0	8.4	2.7	0.13	0.03	0	4.0	8.4	0
	0	23	0	0	25	0	0	25	0
	3.0	4.0	2.7	1.9	1.9	2.4	2.9	4.1	2.4
	0	0	0	0	0	0	0	0	0
	0	8.0	8.0	0	11.0	11.0	0	11.0	11.0
	29	69	90	38	78	123	41	79	124
	1.95	2.34	1.47	1.95	2.71	2.12	2.05	3.08	2.63
	x	x	x	x	x	x	x	x	x
	14.14	29.66	9.69	0.46	0.12	0	14.14	29.66	0
	7.0	5.3	6.9	6.4	5.3	7.5	6.4	5.6	7.2
	0	120	288	0	0	0	0	52	116
	x	x	x	x	x	x	x	x	x
	0	0	0	150	360	175	150	360	175
	←			2.9	6.0	7.3			→
	21	135	142	6	5	6	10	37	101
	←			3.2	3.1	3.6			→
	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x
	←			850	1920	4140			→
	←			0	210	440			→
	38	31	26	2	8	26	7	23	16
	0	51	0	0	51	0	0	51	0
	2.0	2.7	2.0	1.3	2.6	2.0	2.7	4.0	6.1
	80	97	62	11	27	32	39	57	55
	x	x	x	x	x	x	x	x	x
	30	0	0	15	0	0	Same	as	EQ
	1100	2700	5200	1100	2700	5000	1200	2900	5200